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Is the Aging of Society a Threat to Japan?

-Increasing Productivity in the Next Decade is the Key-

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Chapter 1　Statement of Problem and Overview of Study

Hiromichi Shirakawa

[Abstract]

The main purpose of this report is to respond to the question of what effect the aging of Japan's society and the decline of its population will have on the nation's economic productivity. It is highly possible that the aging and decline of the population will result in a decline in the growth of productivity in the Japanese economy. However, there is little likelihood that economic growth will be affected by a decline in productivity due to the aging of the population within the next decade. In the short-term at least, there is therefore no reason to emphasize the threat represented by the aging of the society. However, because growth in productivity will become negative from the latter half of the 2020s onwards, it will be essential to make efforts to increase the capacity for technological innovation and boost labor productivity within this ten-year period.

1. Statement of the Problem

It is considered that the aging of Japan's population, or in fact the aging and decline of its population, will create a variety of problems for the economy.

First, it is possible that a worsening of the state of social security finances will result in a downward trend in domestic investment. If an increase in social security expenditure is authorized and the government attempts to stop an overall worsening of finances throughout its departments, unless quite significant tax increases are imposed, it will be necessary to drastically reduce discretionary expenditure, in particular public spending. If gross investment (gross fixed capital formation) declines as a result, it is quite possible that a deterioration in the quality of social capital, among other factors, will create downward pressure on economic growth.

Second, it is possible that the Japanese economy will experience a decline in productivity. While there are a number of differing concepts of productivity, for example labor productivity and total factor productivity (see Box 1 at the end of this chapter for definitions of productivity and representative indexes of productivity), we cannot deny the possibility that the aging and decline of Japan's population may reduce the capacity to produce value added per worker and cause a decline in the capacity for technological innovation in the economy as a whole.

The possibility that productivity might decline with the aging and decline of the population represents a considerable threat to the corporate sector due to reduced competitiveness and profitability. Profitability will be further affected if the company employs a seniority-based wage system.

It may be assumed that a decline in corporate profits will also function to limit future-oriented investment in facilities and in research and development, in addition to the employment of young workers. From the medium- to long-term perspective, this would create a vicious circle which would put further downward pressure on productivity.

If the aging and decline of the population results in declining investment and reduced productivity, a considerable decline in the trend growth rate of the Japanese economy will be unavoidable. This will increase the probability of financial collapses, and the government will ultimately be forced to implement major tax increases or adopt aggressively inflationary policies. It is not easy to offer an answer to the question as to whether Japan's future economy and society can withstand these types of policy shock, but it will at least be necessary for the nation's citizens to resign themselves to a significantly lower standard of living than that which they presently enjoy.

Against this background, it is extremely important to analyze how the ongoing aging and decline of the population will actually affect future productivity in the Japanese economy, how it will affect the average wage of workers, and how these factors will impact on profitability and revenue in the corporate sector. This is precisely the purpose of this report.

Two basic scenarios can be projected: Either productivity will decline but average wages will increase, exerting a strong downward pressure on corporate profits, or productivity will transition stably and average wages will decline, which will function to increase corporate profits. If the first scenario eventuates, many Japanese companies will be forced to revise their seniority-based wage systems in the face of declining productivity; if the second scenario eventuates, many companies will receive a "bonus" from the aging of their workers, which should be used to increase productivity through increased investment in research and development and increased hiring of young employees.

2. Summary of Empirical Analyses

(1) Empirical analysis of relationship between rate of population change and productivity (TFP): Chapter 2

Does population decline result in reduced productivity (considered as TFP, which may also be taken as a measure of technological progress)? If it does, this represents a serious threat to the Japanese economy, given that the speed and the magnitude of the decline of Japan's population is greater than in other advanced nations.

The impact of population decline on productivity can be considered from a variety of perspectives: the reduction in the collective capacity of the workforce due to population decline may result in a decline in productivity; a decline in the youthful workforce may result in a reduction in creativity and enterprise in the economy as a whole, thus causing a decline in productivity; or, the necessity to make greater use of production factors other than labor power may spur technological progress and thus increase productivity in the economy as a whole. The perspective proposed by Kuznetz (1960), among others, that larger populations contain a greater number of potential innovators in addition to promoting a higher level of intellectual exchange, specialization, and division of roles, thus increasing the rate of technological progress, must also be taken into consideration.

Based on these considerations, the present study proposed three hypotheses and subjected them to empirical analysis using panel data for OECD member nations and the G10 and time series data for Japan. These hypotheses were: 1) the working population increases with the size of the total population, resulting in a higher rate of technological progress; 2) that the rate of technological progress will decline with increases in the cost of technological development due to the aging of the society and other factors; and 3) that the rate of technological progress will be higher the more easily technologies can be introduced from other countries (the momentum of technological progress increases in proportion to the level of economic openness).

The main conclusions resulting from this empirical analysis are as follows:

■ An empirical analysis for the G10 nations and 19 OECD nations (panel data analysis using MFP) showed that a positive relationship exists between total population and the rate of increase in productivity, and a negative relationship exists between the ratio of the elderly population (aged 65 and above) to the total population and the rate of increase in productivity. A positive relationship was also determined between the level of economic openness (the percentage of GDP represented by total imports and exports) and the rate of increase in productivity. These results supported the three hypotheses outlined above.

- Despite some degree of statistical unreliability, an empirical analysis for Japan (a cointegration analysis of time series data using TFP) showed that the size of the working population and the level of economic openness both had a positive effect on the rate of increase in TFP. This means that if the working population declines, the rate of increase of TFP will decline, but if the level of economic openness increases, the rate of increase in TFP will also increase.
- A simulation was conducted for the future rate of increase in TFP in Japan based on the results of these empirical analyses. This simulation indicated a TFP growth rate of -0.6% in 2030 based on median working population estimates (a working population of 60.91 million in 2030, as projected by the National Institute of Population and Social Security Research). This result assumes no change in the level of economic openness from the average figure for the period 2002-2007. The simulation showed that Japan's rate of increase in TFP would become negative in the latter half of the 2020s.

As the foregoing discussion indicates, the empirical analyses conducted as part of this project showed a broadly positive relationship between the size of the total population and the size of the working population and the rate of increase in productivity (measured as TFP or MFP, and considered as an indicator of the rate of technological progress) for advanced nations including Japan. They also demonstrated the possibility that the continuing decline in Japan's working population will see its rate of increase in productivity, presently around 1%, decline to a negative level within the next 20 years.

(2) Empirical analysis of the relationship between average worker age and productivity (TFP): Chapter 3

The effect of the aging of society on TFP at the macro level can also be analyzed from the perspective of the relationship between the average age of workers (or the age structure of the working population) and productivity (TFP). It may be assumed that there are average worker ages or specific age structures of the working population at which the potential for technological development and the level of technological progress reach their peaks for specific industries and the economy as a whole. When these average ages are exceeded, or are not reached, specific industries and the economy as a whole are unable to maximally exert their capacity for technological development.

However, the theoretical framework for the relationship between worker age and productivity is not as well-developed as that for the relationship between population and productivity. It is possible to adopt a perspective based on human capital theory, but it is difficult to develop arguments as clear cut as those deployed in the area of population and productivity.

Nevertheless, attention has been drawn to the relationship between worker age and productivity because it is generally observed that wages increase with increasing length of employment and years of work experience. If recompense for labor in the form of wages changes with worker age and years of work experience, then some relationship should also exist between these factors and productivity. The fact that a comparatively large number of empirical studies of the relationship between worker age and productivity have been conducted can be considered to reflect this way of thinking (see Box 2 in this chapter for more detail regarding this point).

In addition to regressing TFP on the ratio of different age groups in order to consider which worker age groups a relative increase in would stimulate the greatest increase in TFP, the present study employed industrial panel data in order to examine the relationship between average worker age and TFP. The following results were obtained from these empirical analyses:

- A strong possibility exists that TFP will display its maximum increase when there is an increase in the working population aged 40-49. This indicates the possibility that technological capacity in the Japanese economy will maximally increase when there has been a relative increase in the population of workers in their 40s.
- When the relationship between the average age of the working population and TFP is analyzed using industry panel data, the relationship is best described by a nonlinear curve termed an inverse Weibull function. TFP reaches its highest level at an average worker age of a little less than 46.
- As this suggests, there is a strong possibility that technological capacity in the Japanese economy will reach its highest level at an average worker age of a little less than 46, following which the level of technological capacity (the level of TFP) will decline if there is further aging of society as viewed by average age.
- However, the rate of decline in TFP following its peak at an average worker age of a little less than 46 will be comparatively mild
- A similar analysis conducted using median estimates for the working population (National

Based therefore on the results of empirical analyses of the relationship between the average age of the working population and TFP, we may conjecture that the level of TFP of the Japanese economy will gradually increase (i.e., the total technological capacity of the economy will gradually increase) until the average age of workers reaches just under 46, and it can be predicted that TFP will continue to increase until the beginning of the 2020s.

(3) Empirical analysis of labor productivity for different worker age groups: Chapter 4

An empirical analysis concerning the labor productivity of different worker age groups was next conducted. Using panel data for different industry sectors, labor productivity for five-year age groups was estimated based on a linear difference model. The sensitivity of the (change in) output per worker to the ratio of each age group to the worker population was measured. The 15-24 age group was used as the standard age group. If the parameters estimated for the ratio of workers in a specific age group differed significantly from 1, the productivity of that age group was considered to differ significantly from that of the 15-24 age group. In addition, because the purpose was to isolate the effect of labor productivity, capital input and intermediate inputs per worker were added as explanatory variables, and were controlled. The analysis discussed in (2) above had demonstrated that a fixed relationship existed between the average worker age and productivity and the capacity for technological innovation in the economy as a whole. Labor productivity by worker age groups was examined in order to determine whether, against the background of this macro-level relationship, any relationship existed between worker age and the capacity of individual workers to produce added value.

The analysis of labor productivity by age group produced the following results:

- The level of labor productivity is highest for the 45-49 age group. However, the difference between the labor productivity of the 40-44 age group and the 45-49 age group is not great.
- Excluding the fact that labor productivity declines relatively significantly for the 50-54 age group, there is an inverse U relationship between age group and labor productivity.
- The decline in labor productivity after it reaches its peak in the 45-49 age group is relatively mild. Caution must be exercised with regard to the relatively significant decline for the

50-54 age group, but on an all-industry (excluding agriculture and the public sector) basis, the labor productivity of the 55-59 age group is virtually identical to that of the 40-44 age group. Therefore, it is possible that further aging of society will not result in a particularly dramatic decline in labor productivity.

- However, when calculations were conducted for the manufacturing sector alone, while labor productivity peaked in the 45-49 age group, as in the case of calculations conducted on an all-industry basis, the decline in labor productivity in the 55-59 age group was more marked than in all-industry estimates.
- The future trend of labor productivity on a macro level was simulated using the calculated values of labor productivity for each age group. Results for a scenario which assumed that the working population would change in line with the median projections of the National Institute of Population and Social Security Research indicated that labor productivity would maintain positive growth until around 2020. This results from the fact that the second-generation baby boomers will reach their 40s, their period of peak labor productivity, between 2015 and 2025.

When labor productivity was used as the criterion, an empirical analysis showed that in Japan, on an all-industry basis, productivity increases until a worker age of 45-49, and labor productivity will therefore continue to increase until around 2020. While it is predicted that the rate of growth of TFP will become negative in the latter half of the 2020s as a result of the shrinking of the working population, as indicated above, this result showed that the growth rate of labor productivity will become negative slightly earlier, in the former half of the 2020s. It is of considerable interest that this result accords with the result of the analysis of the relationship between worker age and TFP (the rate of growth of TFP will become negative in the former half of the 2020s).

(4) Empirical analysis of relationship between average worker age, wages, and company revenues: Chapter 3

The analysis discussed in (2) above showed:
(a) that the rate of technological progress in the economy as a whole, i.e. considered from the perspective of TFP, is most likely to increase when there is a relative increase in the working population aged between 40 and 49; (b) the level of TFP is highest when the average age of workers is just under 46; and (c) because of this, despite the ongoing aging of the population, the existence of the second-generation baby boomers, among other factors, means that TFP in the Japanese economy will display a relaxed growth trend until the beginning of the 2020s.

Put simply, when considered from the perspective of TFP, or technological progress, the aging of Japanese society does not represent a significant threat to the nation’s economy in the coming period of slightly over a decade.

If, then, TFP does display a relaxed growth trend for the next decade, what trend will be displayed by average wages (real wages) in the same period?

An analysis of the relationship between average real wages, the worker age structure, and the average age of workers indicated that when the ratio of older workers aged 50 and above increased, the downward pressure on real wages was greater than the downward pressure on TFP. An analysis of the relationship between the average age of the working population and real wages using industry panel data (using an inverse Weibull function) showed that while the level of real wages reaches its maximum at an average worker age of just under 44, the rate of decline in the level of real wages due to the aging of the society is greater than that of TFP.

This means that, when considered from the macro perspective, the level of real wages reaches its peak at an average age of the working population two years lower (younger) than that at which the level of TFP reaches its peak; however, its subsequent rate of decline as the aging of society proceeds is greater than that of TFP. The important point here is that the average age of the working population in 2006 (44.0) had already, albeit very slightly, exceeded the average age for the peak level of real wages. Therefore, as considered from its relationship with the average worker age, the level of real wages has already entered its phase of decline. Thus, by complete contrast with the outlook for the level of TFP, which is projected to increase until the beginning of the 2020s, the level of real wages is already trending downwards.

This difference in the future trends of TFP and real wages intuitively suggests that corporate profits will tend to display an upwards trend. In fact, assuming as preconditions that the TFP growth rate and the real GDP growth rate correspond, that the future working population accords with median estimates of the future population (i.e. there is no change from 2008 figures in rate of employment by age group), there is no change in working hours, and GDP deflators maintain their past average rates of growth, estimation of the future trend of the ratio of nominal labor costs to nominal GDP shows a downward tendency. Considering that it is very likely that there is an inverse correlation between the ratio of nominal labor costs to nominal GDP and the ratio of corporate revenues to nominal GDP, this indicates that the share of corporate revenues in the economy will trend upwards.

This is to say that as the aging of society proceeds, there is a strong possibility that there will be a transition in the distribution of income from the household to the corporate sector. This suggests that the majority of companies will receive a “bonus” from the aging of society (it should be remembered here that this discussion only concerns the distribution of income; it is unclear whether there will be an increase in corporate income in absolute terms), and from this perspective, it seems highly likely that Japanese companies possess sufficient margin to increase their investment in research and development and their employment of younger workers in order to avoid a future decline in productivity.

(5) Aging of society and employment of the young: Chapter 5

Future estimations of TFP and real wages suggest that the ratio of corporate income to GDP will trend upwards, and there is a strong possibility that in this sense the corporate sector will receive a “bonus” as a result of the aging of society. It can therefore be considered possible for Japanese companies to recirculate this “bonus” to the household sector in the form of more active employment of younger workers.

We may therefore enquire as to what type of stance Japanese companies have adopted with regard to employment of young people up to the present.

It has been suggested that under a seniority-based wage system, the progressive aging of society will threaten company profits, and will therefore function to restrict employment of young people. However, the analysis of wage curves (the relationship between average employee age and real wages) conducted in this report indicates that real wages peak at an average employee age of slightly less than 44 and decline rather rapidly after this age, demonstrating that seniority-based wage systems are not standard in Japan.

Given this, it is highly likely that the aging of society has not directly restricted the employment of young people up to this point.
In fact, the present report reexamines the “replacement effect” theory, which suggests that the existence of middle-aged and older workers reduces employment opportunities for young people, from a variety of perspectives and finds no evidence which strongly supports this theory.

Specifically, 1) an analysis of the employment accession rate produced no clear evidence that employment opportunities for young people are being sacrificed in order to maintain employment of middle-aged and older workers; 2) an analysis of the net inflow of young workers indicated the possibility that companies are adjusting their employee ratios in order to achieve the optimum age structure; and 3) an analysis of industry panel data showed that the rate of growth in employment of young people tends to be higher the more the employee age structure tends towards middle-aged and older, and that industries in which there is a high proportion of middle-aged and older workers are actually reducing their employment of these workers.

Summing up, we may assert that empirical analyses support the notion that there is a strong possibility that Japanese companies are adjusting the ratios of their employee intake in order to achieve an optimum employee age structure. This fact suggests the possibility that the companies are somehow aware that an employee age structure exists which will enable the maximum level of productivity will be achieved, and are acting in accord with this awareness in taking measures to optimize their age structures. We therefore cannot rule out the possibility that the further aging of society in future will increase employment opportunities for young people. In addition, it is highly possible that companies will be placed in an advantageous position in terms of the distribution of income, and this may also act as a factor in promoting increased employment opportunities for young people in future.

However, we do not know the absolute level of increase in employment among young people which will result from companies seeking to optimize their employee age structure. In particular, it is possible that the trend observed at present will continue, and an ongoing long-term recession will reduce the level of employment of young people.

3. Conclusion and Policy Implications

The results obtained from the empirical analyses conducted in this report can be summarized as follows:

1) There is a strong possibility that the decline and aging of the nation’s population will reduce the growth of productivity in the Japanese economy. However, whether considered as TFP or labor productivity, the productivity growth rate will not reach a continuing negative level until the first half of the 2020s.
2) It is therefore unlikely that the decline in productivity resulting from the decline and aging of the population will dampen the rate of economic growth in the coming period of approximately one decade. Given this, the threat represented by the aging of society should not be over-emphasized in the short-term.
3) However, it is predicted that the negative effect of the aging of society − an ongoing

negative rate of growth of productivity – will become manifest from the latter half of the 2020s, and it will therefore be necessary in the coming period of approximately one decade to make efforts in order to increase the capacity for technological innovation and labor productivity in the economy.

4) Specifically, on the micro-economic level, companies should make active efforts to increase their number of full-time employees, and to enhance in-house training, targeting older employees also. It would also be desirable for the government to actively contribute to employment training programs. Measures of this type may be expected to ameliorate the future decline in productivity.
5) On the macroeconomic level, among other measures, it will be essential to increase the level of economic openness and open the labor market in order to increase the capacity for technological innovation, and to reconsider immigration policies and adopt policies to increase the birthrate in order to increase the population.

The results of the analyses conducted in this report suggest a comparatively bright outlook for employment among young people and investment in research and development. This is because they indicate the possibility, based on specific preconditions (that TFP determines the real GDP growth rate, etc.), that the share of labor costs in nominal GDP (one measure of labor's relative share) will trend downwards in future, and there is therefore a strong possibility that the share of corporate profits in GDP will consequently increase. This may be termed a "bonus" from the aging of society. However, this increase in corporate profits does not only bring with it potential for increased employment of young people, but may also stimulate investment in research and development. This can be expected to further increase TFP. The important thing will be not to focus exclusively on the negative aspects of the aging of Japanese society, but to also bring its positive aspects into perspective.

BOX 1: Looking at Productivity

Hisakazu Kato

1. Defining productivity

The term productivity is frequently used, but it is a word with a very diverse set of significations. Generally, productivity is interpreted as the ratio of a certain amount of output to a certain amount of input, and the productivity growth rate refers to the rate of change in productivity understood in this way. As will be clear, a variety of definitions of productivity are possible, depending on what type of inputs are used as the indices for productivity measurements, and what type of data is selected to represent the outputs.

The major question when measuring productivity is what type of input is selected. Depending on whether productivity in relation to the output is measured on the basis of a single factor or a group of factors, we can distinguish productivity into single-factor productivity (SFP) and multi-factor productivity (MFP). If labor indices are used as the input, labor productivity is measured, and if capital indices are used as the input, capital productivity is measured. Multi-factor productivity is measured using a combination of inputs, for example labor and capital, or labor, capital, and intermediate inputs (raw materials, energy, etc.). Furthermore, the definition of productivity will differ depending on how output is defined, whether on a value-added basis, or on a product basis, incorporating intermediate inputs. Another important point in addition to the above is the scope selected for the measurement of productivity – i.e. whether company level, industry level, or national level.

Table 1, based on a table presented in *Measuring Productivity – OECD Manual* (OECD, 2001), classifies these definitions of productivity. In determining what type of productivity will be used in a study, it is necessary to also consider the limitations of the data and other variables.

2. What productivity means

What, then, does "productivity" express? Generally, productivity is taken to express parameters such as technological progress. However, it cannot be taken as simply standing in for technological progress. Productivity is, of course, used as a proxy variable for technological progress, but productivity also encompasses, for example, increases in efficiency or cost reductions achieved under existing technological conditions (i.e. at a fixed technological level).

In addition, in the case of MFP (to be discussed below), “something extra” in addition to the contribution of the inputs, or a “residual,” is included among the factors expressed by productivity, making it difficult to give the term a single, all-encompassing definition.

Figure 1: Overview of main productivity measures

Type of output measure	Type of input measure			
	Labour	**Capital**	**Capital and labour**	**Capital, labour and intermediate inputs (energy, materials, services)**
Gross output	Labour productivity (based on gross output)	Capital productivity (based on gross output)	Capital-labour MFP (based on gross output)	KLEMS multifactor productivity
Value added	Labour productivity (based on value added)	Capital productivity (based on value added)	Capital-labour MFP (based on value added)	-
	Single factor productivity measures		**Multifactor productivity (MFP) measures**	

Source: OECD(2001), "Measuring Productivity -OECD Manual"

3. Representative Indices of Productivity

(1) Labor productivity

Labor productivity expresses changes in the level of output (either output of products or output of added value) produced by the input of a given unit of labor. This is the most representative index of productivity, but caution must be exercised when using it, as it can be affected by changes in capital, technological progress, or (when the output is a product) intermediate inputs.

(2) Capital productivity

Capital productivity expresses changes in the level of output produced by the input of a given unit of capital. Like labor productivity, capital productivity is influenced by other factors, being affected by changes in the amount or quality of labor and intermediate inputs.

(3) Multi-factor productivity (MFP)

To find MFP, total input is determined as a sum of capital and labor inputs weighted for their respective shares in total costs; the difference between the rate of growth of the output and the rate of growth of the total input is MFP. This represents the degree of increase in output due to the contribution of factors other than an increase in inputs.

MFP is taken to be a proxy variable for technological progress, but it does not express the level of technological progress in itself. MFP incorporates representative elements of technological progress, but also the level of economies of scale and improvements in efficiency, etc., in addition to measurement error.

The Solow residuals employed in growth accounting are generally calculated with one category of labor and capital as input and termed total factor productivity (TFP). This is incorporated in the concept of MFP.

BOX 2: Survey of Literature concerning Employee Age and Productivity

Kensuke Miyazawa

1. Background

Theoretical consideration of the relationship between worker age and productivity can be considered to extend back to the theory of human capital advanced by Becker et al. (1964)[*1]. According to this theory, education and on-the-job training represent investments that will increase future labor productivity, and as such do not differ from investments in physical capital. Assuming that the discounted cash flow of the future revenues from investments in human capital exceed their cost, profits can be increased by making these investments. The profit from education appears in the differences in the salaries available at different levels of education; the costs are the expenses associated with education and the income foregone by not working. By contrast, it is the increase in wages with increasing age or years of experience that can be considered to express the profit from on-the-job training.

Mincer (1974) is one representative study of wages, age, and years of experience on the job. In this study, Mincer showed that if wages are regressed on years of education and years of experience, the work experience coefficient is positive. If wages are considered as reflecting productivity, this would indicate that worker productivity increases with increasing experience. This accords with the theory of human capital.

However, the possibility of short-term disjunctures between earnings and productivity has also been indicated. According to the incentive contract model proposed by Lazear et al. (1979), when uncertainty exists with regard to the relationship between workers' level of effort and the resulting outcomes, contracts may be formed under which a worker receives a wage that does not match his or her productivity when young, but exceeds his or her productivity when the worker reaches the middle or older age bracket. If the worker's employment will be terminated if it is realized that his or her level of effort has declined, and the employee will then be unable to receive the earnings that he or she should have received in the future, this can be seen as functioning to control incentives for workers to reduce their level of effort. Lazear and Moore (1984) demonstrated the possibility, through a comparison with the earnings profiles of self-employed individuals (where no issue of asymmetry exists between the worker and information), that incentive contracts are actually formed.

2. Analyses employing micro-data

The theories discussed above necessitated a framework that would enable consideration of the relationship between worker age and productivity without the use of earnings data. The production function approach pioneered by Hellerstein and Neumark (1995) answered this need. Using micro-data encompassing information on both workers and companies (or workplaces) termed "employer-employee matched data sets", Hellerstein and Neumark succeeded in estimating the productivity of workers in different age groups by estimating production functions for the company with consideration of heterogeneity in workers' ages. At the same time, it became possible to study the validity of the theory advanced by Lazear et al (1979) by comparing wage profiles and productivity.

Since the work of Hellerstein and Neumark (1995), Andersson et al. (2002), Crepon et al. (2002), Dostie (2006), Haegeland and Klette (1998), Haltiwanger et al. (1999), Hellerstein and Neumark (2004) , Hellerstein, Neumark, and Troske (1999) , Ilmakunnas et al. (2004), and Malmberg et al. (2008) have all conducted studies using similar frameworks. The results of these studies are basically identical in indicating that productivity considered by worker age displays an inverse U shape, peaking between the ages of 35 and 54. Productivity between the ages of 35 and 54 is between 10 and 20% higher than productivity at 34 and below. The majority of studies showed that the earnings profile rises more steeply than productivity, indicating the strong possibility that incentive contracts of the type described by Lazear (1979) are being formed.[*2]

A similar study has been conducted in Japan by Kawaguchi et al. (2006). The researchers formulated employer-employee matched data sets by matching the Census of Manufactures (Form A, 30 employees or more) with the Employment Structure Survey. The results of this study resembled those of preceding studies. While some variations existed between industries, it was found that worker productivity tended to reach its peak at 20 years of work experience, following which it declined. Productivity at its peak was approximately 40% higher than productivity at zero years of experience. Wage gradients rose more sharply than productivity, and in many cases there was no decline in earnings up to the 40th year of work experience. The argument put forward by Lazear (1979) can therefore also be considered to hold true for Japan.

3. Analyses using macro-data

In addition to the company- and workplace-level studies discussed above, analyses using macro-level data have also been the focus of attention. The background to this type of research can be found in discussions of economic disparities between advanced and developing nations. Recent empirical analyses of convergence between advanced and developing nations have not demonstrated the type of convergence hypothesized by the simple neoclassical model. Significant disparities in productivity are known to be the reason for this, and differences in the age structures of the workforces have been focused on as a causative factor in these disparities.

Using panel data for the GDP, TFP, and worker age structures of non-oil-producing countries, Feyrer (2007, 2008) analyzed the effect of the population structure by regressing GDP and TFP on dummy variables for the worker age structure. A similar analysis was conducted by Werding (2007). These studies also showed that the productivity profile described an inverted U shape, with worker productivity reaching its peak when workers were in their 40s. According to Feyrer (2007), advanced nations are characterized by the high average age of their workers, and between one-quarter and one-third of the disparity in productivity between OECD member nations and low-income nations can be explained as an effect of the worker age structure.

The main point of difference between the results of these analyses and analyses using micro-data is the quantitative effect of the worker age structure. As indicated above, analyses using micro-data have demonstrated that changes in age can increase the productivity of each worker between approximately 10% and 40%. This means that a 1% increase in the number of workers in the most productive age group could increase productivity at the macro-economic level by 0.1% to 0.4%. By contrast, the studies conducted by Feyrer (2007, 2008) and Werding (2007) indicate that a 1% increase in the working population in the 40-49 age group could increase productivity at the macro-economic level by up to 3%.

Feyrer (2008) emphasizes externalities to the worker age structure as the reason for this divergence in results. Feyrer suggests two potential mechanisms for these externalities. The first is that a higher concentration of inventions tends to be produced by individuals in their 40s, and therefore an innovation externality can be considered. However, the aging of the baby boom generation has not generated a significant change in patent trends. This hypothesis therefore lacks explanatory power.

The other potential mechanism is a change in the age structure of managers. When the baby boom generation began to participate in the labor market, there was a shortage of experienced managers, and it is therefore possible that employees in the middle-aged and older age groups who lacked ability were selected for managerial positions. This problem was resolved when the baby boomers gained a certain degree of experience and began entering managerial positions. Feyrer (2008) tested this hypothesis using data for U.S. states and cities, but this study did not determine any quantitative effects resembling those of the macro-level analyses. Feyrer (2008) also took Mincer’s wage function (Mincer (1974)) as a subject for comparative study. However, given that the micro-data analyses studied the productivity of companies and workplaces, if the age structure of managers actually did produce an effect, it should also have appeared in the outcomes of these analyses.

We may consider the problem of the studies using macro-level data to be that they reversed causality from productivity to the age structure. The birthrate is declining in the majority of advanced nations, and this can be considered to be a result of economic development. Becker (1960) and Becker and Lewis (1973) point out that as the economy develops, parents tend to emphasize quality over quantity in terms of their offspring, and there is a possibility that this will result in a decline in the birthrate. It is also true in the majority of cases that the mortality rate declines with economic development. When long-term differences in GDP and TFP exist between nations, or economic development is projected in advance, it is likely that there will, accordingly, be a correlation between the present level of aging of the society and the present economic level or the economic growth rate. Under these circumstances, there will be no clear correlation between the ratio of workers aged 50 or older, the ratio of workers in their 40s, and GDP and TFP. According to Feyrer (2008), when an instrumental variable method is used, or when the log level rather than the log difference of TFP, the explained variable, is employed, the difference between the effect of the ratio of workers aged 50 and above and of the ratio of workers in their 40s becomes insignificant, and the argument above may hold true.

[Notes]

*1 Becker (1964) indicates that the human capital concept had its dual origins in Solow residual analysis (Solow (1957)) and discussion of the importance of education as a factor in economic development.

*2 Research conducted prior to 2003 is summarized in Skirbekk (2003).

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Chapter 2　Empirical Analysis of Population and Technological Progress

Hisakazu Kato

[Abstract]

An international comparative analysis was conducted using data for OECD countries in order to study the effect of trends in population size and aging on technological progress (multifactor productivity (MFP) and labor productivity). The results show that MFP rates become higher the larger a country's population or the lower its ratio of elderly citizens. In addition, the results of an analysis of the effect of the size of the working population and the level of economic openness on the rate of increase in total factor productivity (TFP) using time series data for Japan indicated a long-term positive relationship (a cointegration relationship) between the size of the working population and the rate of increase in technological progress (rate of increase in TFP). The future rate of increase in TFP was projected on the basis of these results. Despite a long-term rate of increase in TFP of around 1%, in a scenario in which a significant decline in the working population occurs, it is possible that the growth rate of TFP will become negative in a little over a decade.

1. Introduction

Japan's population is declining, and Japanese society is moving towards a level of aging unique in previous human experience. Population decline and the aging of society are not affecting Japan alone; the majority of advanced nations appear to be entering the same trajectory. This situation gives rise to a simple question: How can we maintain continuing growth under these conditions of population restriction?

In Japan's period of high economic growth in the 1950s and 1960s, the nation boasted a large population of young people, and their diligence in saving was one engine of the nation's economic growth. This is the so-called "population bonus," by which population factors have a positive impact on economic growth. In the future, this situation will be entirely reversed, and long-term economic growth will be in danger from a "population onus." The volume of research on the status of economic growth from the perspectives of the working population and the savings rate defies enumeration. If we consider economic growth from the supply side and base our analysis on simple growth accounting, technological progress represents a third factor, but what effect will population trends exert on technological progress? The purpose of this paper is to empirically examine this question.

Technological progress is realized by means of the outcomes of technological innovation and increases in the quality of capital and labor inputs. An increase in technological progress appears in the short-term as increased productivity, and in the long-term as innovation. Short-term increased productivity and long-term technological innovation contain many differing elements, and historical factors also play complex roles. It is difficult to strictly distinguish the two either in theory or in practice. However, if normal increases in productivity are considered (and these are regarded as technological progress), hypotheses can be formulated regarding the ways in which population factors are involved. This paper will consider short-term productivity increases as representing technological progress, and will study the relationship between recent trends in technological progress, the population, and the working population.

2. The Relationship between Population Growth and Technological Progress

(1) Population decline and technological progress

(A survey of empirical analyses of the relationship between population decline and technological progress)

If the total population or the rate of population growth is positively correlated with technological progress (increased productivity), then the future declines in population projected for Japan and other advanced nations can be expected to result in declines in the rate of technological progress. In Japan, where the speed and the scale of population decline are expected to be greater than in other advanced nations, this is an issue that affects the sustainability of economic growth[*1]. This view of the issue emerged in the latter half of the 1990s, leading to the implementation of a variety of research projects. This section will provide a brief survey of that research.

The Economic Planning Agency (1995) identified three effects of the relationship between technological progress and the working population. The first of these was a decline in collective capacity resulting from the decline in the rate of growth of the working population, due to a loss of economies of scale. The second was a loss of creativity: A decline in the working population and consequently in the young working population would result in a decline in the creativity and enterprise displayed by the young. The third was a promotion of labor-saving efforts: A greater use of production factors other than labor power, including technological progress, would be necessitated, and this would promote technological progress. Based on the above, if the effect of the promotion of labor-saving efforts is greater than the effect of the loss of economies of scale and the effect of the loss of creativity, then the rate of increase in productivity will rise in proportion to the decline in the rate of increase of the working population; on the other hand, if the effect of the promotion of labor-saving efforts is insufficient, then there is a positive correlation between the rate of growth of the working population and the rate of increase in productivity. Employing cross-country data to examine the relationship between the two, this study concluded that the rate of increase in productivity rises in proportion to the decline in the rate of increase of the working population.

Numerous similar studies were conducted following the publication of this study. Yashiro (1999) studied the relationship between the rate of increase in labor supply and the rate of increase in TFP in eight advanced nations between 1980 and 1991, and found a negative relationship between the two. Using average figures for the period 1975-1994 for ten advanced nations including Japan, the then Ministry of Labor (2000) found a significant negative relationship between the rate of increase in the working population and the rate of increase in TFP. A cross-country analysis conducted by the Cabinet Office (2003) using 1981-2000 data for OECD member nations concluded that a loose negative correlation existed between the rate of increase in the number of workers and the rate of increase in TFP.

By contrast, following a detailed analysis of the theoretical relationship between the size of the population and technological progress, Koguro and Morishita (2008) examined panel data for five advanced nations and concluded that a positive relationship existed between the rate of increase in TFP and the total population. This research differed from the research discussed above in using total population rather than the rate of increase in the working population as the explanatory variable.

(2) Formulation of hypotheses for empirical analysis

(The larger the population, the greater the stimulus to technological progress)

This section will set out hypotheses to function as a theoretical model for a study of the relationship between the rate of increase in TFP and the size of the population[*2]. The basic framework is provided by the view, presented for example in Kuznetz (1960) and Simon (1977), that the number of potential innovators increases in proportion to the increase in the population, and that a large population increases the degree of intellectual exchange and spurs specialization and a greater division of roles, promoting technological development. Similarly, Aghion and Howitt (1992) and Grossman and Helpman (1991) see an increase in the size of the population and the consequent expansion of the market as promoting research and development output, and thus as linked to technological progress. However, these studies also indicate that a large population may reduce the efficiency of the process of technological progress due to redundancy of effort and other factors.

We will term the working population L, the segment of the working population participating in technological development L_A, and the segment involved in production L_Y. Therefore,

$$L = L_Y + L_A \tag{1}$$

If $\gamma_A = L_A / L$, the segment of the working population involved in production activities is

$$L_Y = (1 - \gamma_A)L \tag{2}$$

Assuming $Y = AL_Y$ as the simple production function (where A is productivity) and terming output per person y gives us

$$y = A(1 - \gamma_A) \tag{3}$$

Assuming that the rate of technological progress accelerates in proportion with the percentage of the working population involved in technological development, and terming the "cost" of technological development μ, we may hypothesize the relationship expressed in the following equation:

$$\dot{A} / A = L_A \tag{4}$$

Here, μ is a parameter affecting the population of L_A required in order to achieve a fixed rate of technological progress. For example, as the aging of a society proceeds, there will be a relative decline in groupings within the population which generate new ideas; μ will increase, and the rate of technological progress will decline.

Rewriting the equation above as $\dot{A} = (\gamma_A / \mu)L$, and given that $\dot{y} = \dot{A}$ based on the hypothesis that γ_A is constant, then

$$\dot{y} = \dot{A} = (\gamma_A / \mu) \tag{5}$$

Based on this, the working population increases with the size of the total population, and the rate of technological progress also increases. However, if the cost of technological development increases due to the aging of the society or other factors, the rate of technological progress will decline.

It may not be the case, however, that this relationship expresses past historical facts. It cannot be definitely stated that income per capita becomes higher the higher the population of a country. The propagation of technologies is a background factor, and the rate of technological progress will be higher the more easily technologies can be introduced from other countries. It can therefore be considered necessary to incorporate a proxy for the introduction of technologies from other countries as an explanatory variable in an empirical analysis.

In the rest of this section I will examine the relationship between the rates of increase of population and technological progress (productivity) discussed above. First, I will conduct an analysis using panel data for OECD countries, following which I will discuss results obtained using time series data for Japan[*3].

3. Empirical Analysis using OECD Panel Data

An analysis was conducted using OECD panel data in order to study the relationship between the size of the population, the rate of growth of the population, and the rate of increase in productivity (the rate of increase in MFP). First, I provide an overview of the data, followed by a discussion of the results of the analysis.

(1) Data

■Source of data

(Use of OECD data and definition of MFP)

MFP figures published by the OECD were used in the analysis. Figures from the database "MFP based on Harmonized Price Indices for ICT Capital Goods, Capital Input, Cost Shares, Total Factor Input" (2007) were employed. This database contains the results of measurements of MFP for 19 OECD countries from 1985 to 2007. However, some fiscal years are missing from some of the data, and new countries became OECD members during the period covered by the data; for these reasons, the data does not represent a balanced panel data set for the 19 countries[*4].

MFP is defined as the difference between the rate of change in output (Q) and the rate of change in input (X). Equation (6) provides the definition:

$$\ln\left(MFP_t / MFP_{t-1}\right) = \ln\left(Q_t / Q_{t-1}\right) - \ln\left(X_t / X_{t-1}\right) \qquad (6)$$

Here, output is real gross domestic product in the OECD National Accounts, and input is labor power and seven categories of capital stock. The difference between this measure and standard TFP lies in this use of seven categories of capital stock[*5].

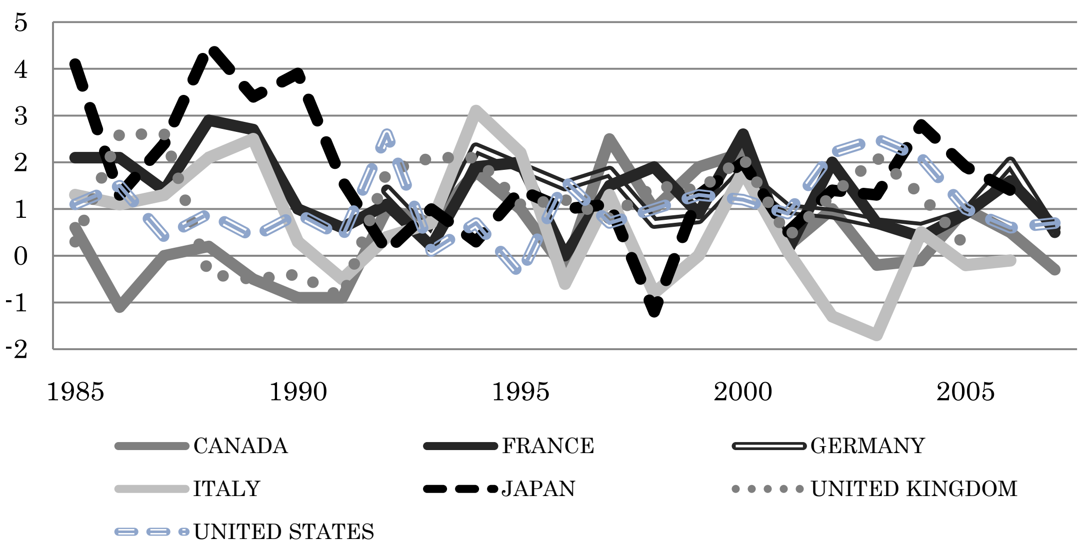
The empirical analysis below uses, in addition to MFP, labor productivity indices formulated on the basis of OECD databases. Labor productivity is the level of GDP per unit of input labor, and its rate of increase was calculated and employed in place of MFP as an index of technological progress. It was calculated based on the GDP for each country published in the OECD Annual National Accounts, using the working populations found in the OECD Labour Force Statistics. Labor productivity was calculated for 29 OECD countries, but certain data were missing and, as in the case of MFP, a balanced panel data set was not obtained[*6]. Data for total population and percentage of the population aged 65 or above were obtained from OECD Labor Force Statistics. When working population and total population were used, they were converted into logarithms.

■Cross-national comparison of MFP

(Japan displayed highest MFP in cross-national comparison)

Figure 2-1 shows changes in MFP for seven major nations (Canada, France, Germany, Italy, Japan, the UK, and the U.S.). Averaged across the period covered by the calculations, Japan displayed the highest rate of increase in MFP at 1.70% (1985-2006), followed by France at 1.36% (1985-2007), and Germany at 1.20% (1992-2007). Canada displayed the lowest rate of increase in MFP at 0.49% (1985-2007). The figure for the U.S. was 1.06% (1985-2007).

Figure 2-1 Changes in MFP in major nations



Source: OECD (2007)

(2) Results of Empirical Analysis

The hypotheses discussed above were examined using the OECD panel data.

■Results of empirical analysis of MFP (1)

(An empirical analysis conducted for 19 OECD nations showed a positive relationship between population and technological progress)

Figure 2-2 shows the results of panel regression for 19 OECD nations, with the rate of increase in MFP as a proxy variable for technological progress. Based on the discussion in section 1.(2) above, the ratio of elderly citizens in the population, the level of economic openness, and the rate of population increase were used as explanatory variables, with total population used as the axis. Of these, the ratio of elderly citizens in the population was used as a proxy variable for the cost of technological development, and was defined as the percentage of citizens aged 65 or above in the total population. The level of economic openness was used as a proxy variable for technological exchange with other countries, and was defined as the percentage of GDP represented by total imports and exports.

Pooled models and random effects models were used in the analysis*[7]. In Case (1-1), pooled regression was applied to MFP on total population, and in Case (1-2) a random effects model was employed. The calculated parameters were negative and significant (-0.288 for the former and -0.254 for the latter), and did not support the hypothesis discussed above. In Cases (2-1) and (2-2), when the ratio of elderly citizens in the population was included, the total population parameters were negative but not significant at -0.163 and -0.037 respectively. Results for the ratio of elderly citizens were negative but accorded with expectations at -0.06 and –0.095 respectively.

Taking the determining factors of MFP into consideration, it was possible that insufficient controls were applied in the selection of explanatory variables. In Cases (3-1) and (3-2), therefore, economic openness was added to the explanatory variables*[8]. For Case (3-1), using a pooled model, a positive result of 0.398 was obtained for the total population parameter, and the result was significant, with a p value of 0.03. The total population parameter was also positive at 0.582 for Case (3-2), using a random effects model. However, the result was not significant, with p= 0.107. By contrast, the ratio of elderly citizens (-0.133) and the level of economic openness (1.450) were both significant for Case (3-2). Results supporting the hypothesis above can therefore be considered to have been obtained for total population, ratio of elderly citizens, and level of economic openness.

Figure 2-2 Effect of population and other factors on rate of increase in MFP: Results for 19 OECD nations

Model	(1-1)	(1-2)	(2-1)	(2-2)	(3-1)	(3-2)	(4-1)	(4-2)	(5-1)	(5-2)
	19 OECD nations									
	Pooled	Random	Pooled	Random	Pooled	Random	Pooled	Random	Pooled	Random
Constant	2.410	2.229	2.651	2.550	-0.080	-0.601	1.326	1.326	0.377	-0.591
	(0.55)	(1.29)	(4.69)	(1.89)	(-0.09)	(-0.38)	(12.6)	(7.01)	(0.82)	(-0.36)
Total Population	**-0.288**	**-0.254**	**-0.163**	**-0.037**	**0.398**	**0.582**			**0.423**	**0.661**
	(-2.27)	(-0.851)	(-1.18)	(-0.12)	(2.196)	(1.613)			(2.36)	(1.81)
Ratio of Elderly Population			-0.060	-0.095	-0.097	-0.133			-0.121	-0.148
			(-2.29)	(-2.40)	(-3.61)	(-3.26)			(-4.36)	(-3.61)
Economic Openness					1.192	1.450			1.177	1.609
					(4.56)	(3.25)			(4.55)	(3.58)
Growth of Population							-0.262	-0.316	-0.404	-0.416
							(-2.03)	(-2.06)	(-3.01)	(-2.66)
R^2	0.010	0.002	0.012	0.017	0.081	0.038	0.011	0.012	0.105	0.065
s.e.	1.334	1.184	1.180	1.180	1.302	1.169	1.336	1.177	1.287	1.158
Sample	369	369	361	361	357	357	369	369	357	357

Notes

1) MFP is the explained variable.
2) Figures within parentheses are t-values.
3) Certain data were missing from the database, and a complete panel data set was not obtained.
4) The period for calculations was 1985-2007.

In Cases (4-1) and (4-2), MFP was explained by the rate of population increase. Section 1.2 assumed a positive relationship between technological progress and the rate of population increase, but the results for Case (4-1) (-0.262) and Case (4-2) (-0.316) are both negative and significant, and do not support the hypothesis.

Cases (5-1) and (5-2) used all of the abovementioned explanatory variables. The pooled regression in Case (5-1) produced a positive result of 0.423 for the total population parameter; this result was significant, with a p value of 0.019. Case (5-2), using a random effects model, also produced a positive result for the total population parameter at 0.661. With respect to other results for Case (5-2), the result of -0.148 for the ratio of elderly citizens and 1.609 for the level of economic openness fulfilled the expected sign conditions, and a significant negative result of -0.416 was obtained for the rate of population growth.

■Results of empirical analysis of MFP (2)

(A positive relationship between population and technological progress was also obtained in the case of G10 nations)

The results in the previous section were obtained from an analysis for 19 OECD nations. Figure

2-3 shows the results of the same analysis conducted for the 10 nations with the largest economic scale from among those 19 (Canada, France, Germany, Italy, Japan, Spain, Sweden, Switzerland, the UK, and the U.S.) *[9].

Figure 2-3 Effect of Population and Other Factors on Rate of Increase in MFP: Results for G10

	(6-1)	(6-2)	(7-1)	(7-2)	(8-1)	(8-2)	(9-1)	(9-2)
	10 largest OECD nations							
Model	Pooled	Randam	Pooled	Randam	Pooled	Randam	Pooled	Randam
Constant	-0.766	-0.945	-0.786	-1.150	-3.127	-7.628	1.189	1.117
	(-0.97)	(-0.65)	(-1.00)	(-0.74)	(-1.89)	(-3.30)	(9.97)	(6.25)
Total Population	**0.370**	**0.406**	**0.549**	**0.753**	**0.984**	**1.979**		
	(2.20)	(1.31)	(2.95)	(2.15)	(3.04)	(4.14)		
Ratio of Elderly Population			-0.061	-0.104	-0.076	-0.165		
			(--2.19)	(-2.89)	(-2.64)	(-4.22)		
Economic Openness					1.038	3.005		
					(1.58)	(3.81)		
Growth of Population							-0.403	-0.309
							(-2.41)	(-1.49)
R^2	0.020	0.010	0.046	0.046	0.061	0.097	0.028	0.011
s.e.	1.083	1.026	1.072	1.005	1.069	0.974	1.080	1.026
sample	203	203	203	203	201	201	203	203

Notes

1) MFP is the explained variable.
2) Figures within parentheses are t-values.
3) Certain data were missing from the database, and a complete panel data set was not obtained.
4) The period for calculations was 1985-2007.

By contrast with the results shown in Figure 2-2, cases (6-1) and (6-2), which also used total population as the sole explanatory variable for MFP, both produced positive results. Case (6-1), for which a pooled regression was conducted, produced a result of 0.370 for the total population parameter; with a p value of 0.029 the result was significant at the 5% level. However, while case (6-2), using a random effects model, produced a positive result of 0.406, the result was not significant, with a p value of 0.193.

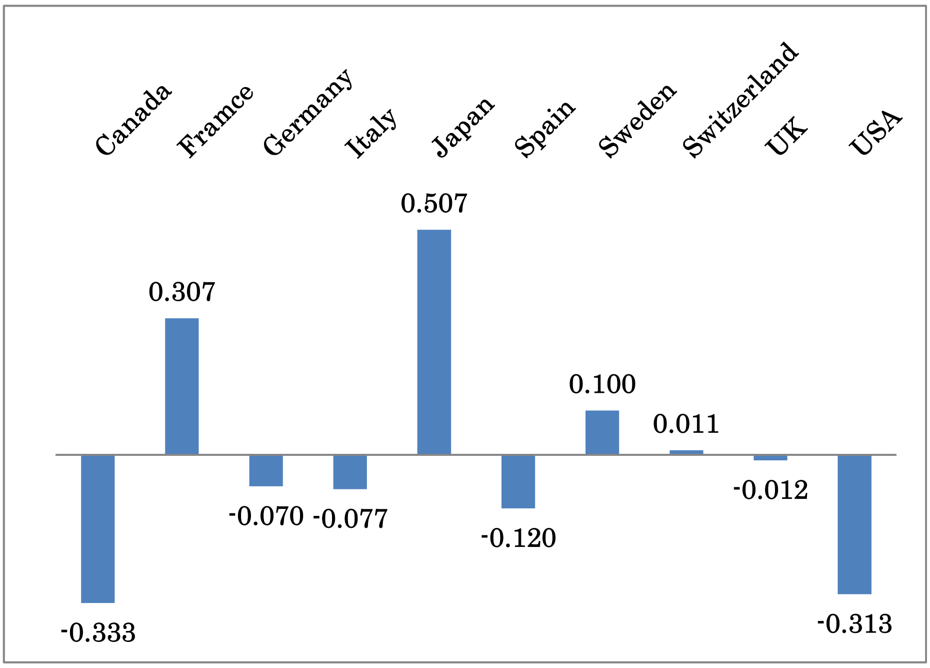
Cases (7-1) and (7-2) included the ratio of elderly citizens as an explanatory variable. Positive results of 0.549 and 0.753 for the total population parameter were produced respectively by the cases, and both results were significant at the 5% level. Negative results of -0.061 and -0.104 respectively were obtained for the ratio of elderly citizens. Cases (8-1) and (8-2) added the level of economic openness as an explanatory variable. The results support the hypothesis, with positive results for the total population parameter, negative results for the ratio of elderly citizens, and positive results for the level of economic openness.

Cases (9-1) and (9-2) explain MFP using the rate of population growth. As in Figure 2-2, negative results were obtained, and these results fail to support hypothesis 3 in the theoretical model. For cases (10-1) and (10-2), calculations were conducted using all of the variables discussed above. The cases produced positive results of 1.374 and 1.773 for the total population parameter, and both results were significant.

The results above show that the total population is almost always a positive parameter in relation to MFP, demonstrating the validity of the positive relationship between the size of the population and technological progress asserted in Chapter 1, Section 2. This result supports the views of Kuznetz (1960) and Aghion and Howitt (1992).

Figure 2-4 compares the cross-section effect for the 10 countries for Case (10-2) in Figure 2-3. The cross-section effect was greatest for Japan at 0.507, followed by France at 0.307, Sweden at 0.100, and Switzerland at 0.01.

Figure 2-4 Cross-section effect for Case (10-2)



■Results of empirical analysis of MFP (3)

(The size of the working population also displayed a positive relationship with technological progress)

The results discussed above used total population and the rate of population growth as explanatory variables for MFP. Figure 2-5 shows the results obtained when the size of the working population and the rate of growth of the working population were substituted as explanatory variables*[10]. A random effects model was used in each case.

For the 19 OECD countries, as in Figure 2-2, negative results were obtained for the working population parameter in the cases in which the working population or the working population and the ratio of elderly citizens only were used as explanatory variables for MFP (Cases (1-3) and (2-3)). The results were positive when the level of economic openness was added as an explanatory variable (0.427 for Case (3-3) and 0.490 for Case (5-3)). However, these results were not significant. Positive and significant results were obtained for the level of economic openness in Cases (3-3) and (5-3) (1.353 and 1.501 respectively). A negative result of -0.066 was recorded for the rate of growth of the working population when included as an explanatory variable in Case (5-3).

Figure 2-5 Effect of working population and other factors on MFP

Model	(1-3)	(2-3)	(3-3)	(5-3)	(6-3)	(7-3)	(8-3)	(10-3)
	19 OECD Nations				10 largest OECD nations			
Constant	2.586	2.967	0.186	-0.026	-0.681	-0.701	-6.269	-6.077
	(2.17)	(2.38)	(0.123)	(-0.02)	(-0.49)	(-0.48)	(-2.88)	(-3.20)
Working population	**-0.364**	**-0.159**	**0.427**	**0.490**	**0.374**	**0.689**	**1.809**	**1.744**
	(-1.23)	(-0.49)	(1.186)	(1.307)	(1.19)	(1.94)	(3.77)	(4.24)
Ratio of Elderly Population		-0.091	-0.126	-0.132		-0.099	-0.152	-0.130
		(-2.30)	(-3.13)	(-3.22)		(-2.74)	(-4.02)	(-3.85)
Economic Openness			1.353	1.501			2.738	2.559
			(3.06)	(3.21)			(3.55)	(3.45)
Growth of Working population				-0.066				-0.146
				(-1.04)				(-1.92)
R^2	0.004	0.018	0.042	0.045	0.007	0.042	0.097	0.096
s.e.	1.183	1.179	1.170	1.168	1.028	1.008	0.981	0.998
sample	369	361	357	357	203	203	201	201

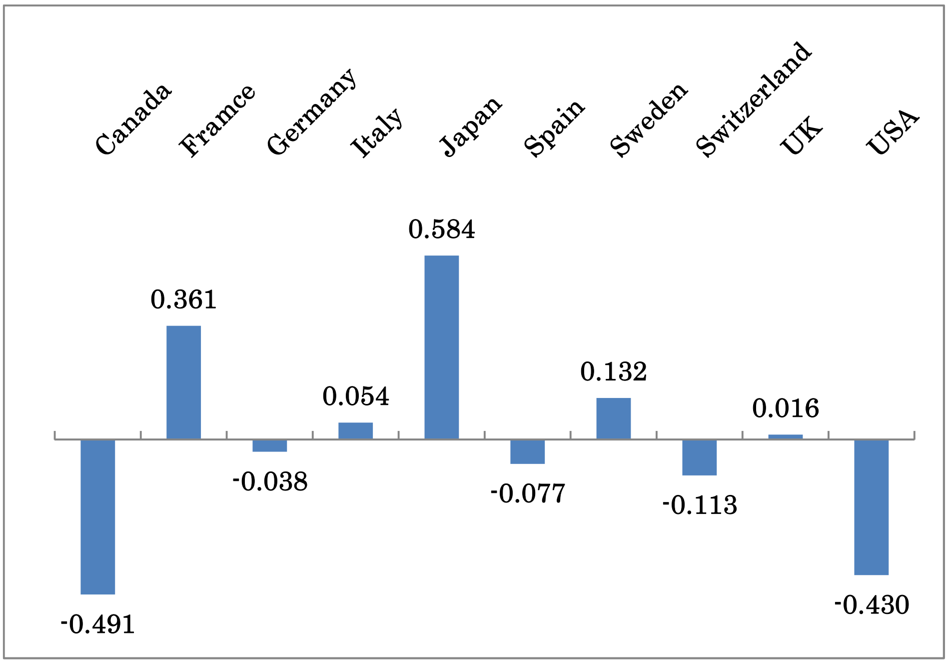
Notes

1) Only a random effects model was used.
2) MFP is the explained variable.
3) Figures within parentheses are t-values.
4) Certain data were missing from the database, and a complete panel data set was not obtained.
5) The period for calculations was 1985-2007.

The working population parameter was positive for the 10 largest OECD nations in all cases. The total population parameter was significant at 1.809 for case (8-3). For the same case, significant results were recorded for the ratio of elderly citizens and the level of economic openness, at -0.152 and 2.738 respectively. Case (10-3) adds the rate of growth of the working population as an explanatory variable, and obtains a negative result of -0.146 for this parameter. For the other explanatory variables, there is almost no difference between case (10-3) and case (8-3).

Like Figure 2-4, Figure 2-6 shows the cross-section effect for 10 nations, this time for case (10-3). Again, the cross-section effect was greatest for Japan at 0.584, followed by France at 0.361, and Sweden at 0.132.

Figure 2-6 Cross-section effect for Case (10-3)



■Results of empirical analysis of labor productivity

(The same conclusion is obtained when labor productivity is substituted for rate of increase in MFP)

The analysis discussed above was conducted for the rate of increase in MFP as the explained variable. It was decided to modify the definition of productivity employed and to conduct an analysis for labor productivity. Figure 2-7 shows the results of this analysis.

When the total population was employed to explain labor productivity for 19 OECD nations (Cases (1-4) and (2-4)), the results for the working population parameter were negative and not significant. When the ratio of elderly citizens and the level of economic openness were added as explanatory variables (Cases (3-4) and (5-4)), the working population coefficient became positive but not significant. The results did not support the hypothesis outlined above.

However, the results obtained for the 10 largest OECD nations do in general support the hypothesis. Case (7-4) takes the working population and the ratio of elderly citizens as explanatory variables, and obtains significant results of 0.989 and -0.145 respectively for these parameters. This indicates a positive relationship between the size of the working population and labor productivity. Case (8-4) adds the level of economic openness as an explanatory variable, and Case (10-4) further adds the rate of growth of the working population. The results for the working population parameter in both these cases (1.413 and 1.924) were both positive and significant.

Figure 2-7 Effect of working population and other factors on labor productivity

	(1-4)	(2-4)	(3-4)	(5-4)	(6-4)	(7-4)	(8-4)	(10-4)
	19 OECD nations				10 largest OECD nations			
Constant	3.214	4.059	3.230	3.300	-0.514	-0.621	-2.543	-4.627
	(2.58)	(3.09)	(2.17)	(2.26)	(-0.31)	(-0.34)	(-0.96)	(-1.94)
Working Population	**-0.249**	**-0.161**	**0.002**	**0.040**	**0.510**	**0.989**	**1.413**	**1.924**
	(-0.78)	(-0.49)	(0.01)	(0.117)	(1.341)	(2.26)	(2.37)	(3.59)
Ration of elderly Population		-0.095	-0.105	-0.122		-0.145	-0.174	-0.203
		(-2.22)	(-2.37)	(-2.78)		(-3.55)	(-3.69)	(-4.72)
Economic Openness			0.396	0.700			0.923	2.108
			-1.010	(1.79)			(1.01)	(2.48)
Growth of Working Population				-0.236				-0.429
				(-4.92)				(-5.93)
R^2	0.001	0.009	0.011	0.051	0.008	0.059	0.064	0.187
s.e.	1.732	1.739	1.750	1.713	1.255	1.220	1.224	1.133
Sample	611	611	578	577	230	224	220	219

Notes

1) A random effects model was used in all cases.
2) Labor productivity is the explained variable.
3) Figures within parentheses are t-values.
4) Certain data were missing from the database, and a complete panel data set was not obtained.
5) The period for calculations was 1985-2007.

Figure 2-8 Cross-section effect (Case (10-4))

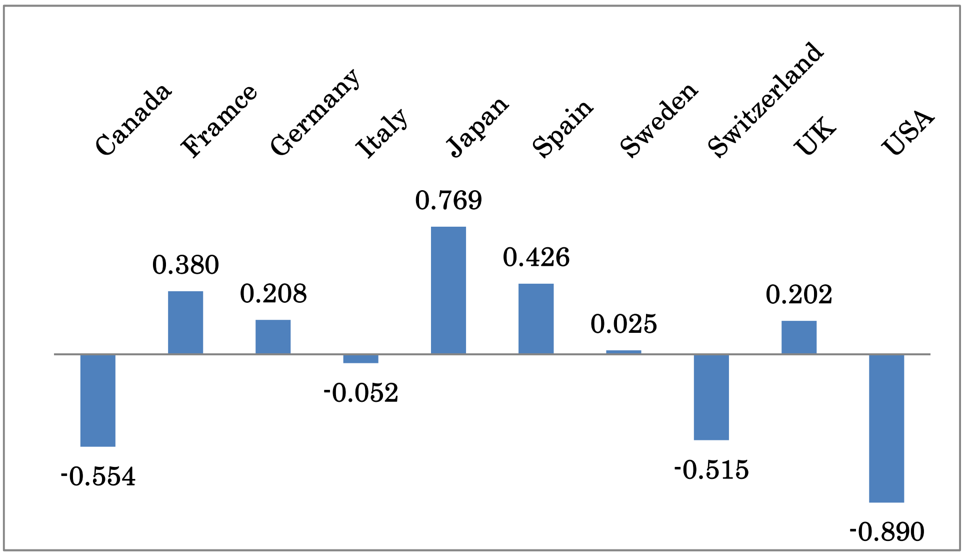


Figure 2-8 shows the cross-section effect calculated for the results of Case (10-4). The cross-section effect was greatest for Japan at 0.769, followed by Spain at 0.426, and France at 0.380.

These results indicate, as suggested in the hypotheses outlined in Section 1.2, that a positive relationship exists between technological progress and the size of the population for advanced nations. This supports the hypothesis of Kuznetz (1960) and others that the size of markets increases in proportion to the size of the population, thus intensifying intellectual exchange and increasing the pool of potential innovators. In addition, the fact that the ratio of elderly citizens, considered as a cost of technological development, has a negative effect and the level of economic openness, which is a proxy variable for the propagation of technology, has a positive effect in relation to technological progress, also basically supports the theoretical model.

4. Verification of Model using Time Series Data for Japan

An analysis conducted using panel data for advanced nations demonstrated the existence of a positive relationship between population size and technological progress. This section will consider whether an analysis conducted for Japan using time series data modifies this conclusion.

(1) Data

■Rate of increase in TFP in JIP Database

(Rate of increase in TFP in JIP data: Trends and characteristics)

Here, the rate of increase in TFP in the macroeconomy as a whole as recorded in the JIP Database will be used as a proxy variable for technological progress*[11]. The 2008 edition of the JIP Database recorded the rate of increase in TFP from 1973 to 2005. 33 samples were taken.

Figure 2-9 Trends in rate of increase in TFP in JIP data and component analysis (HP filter)

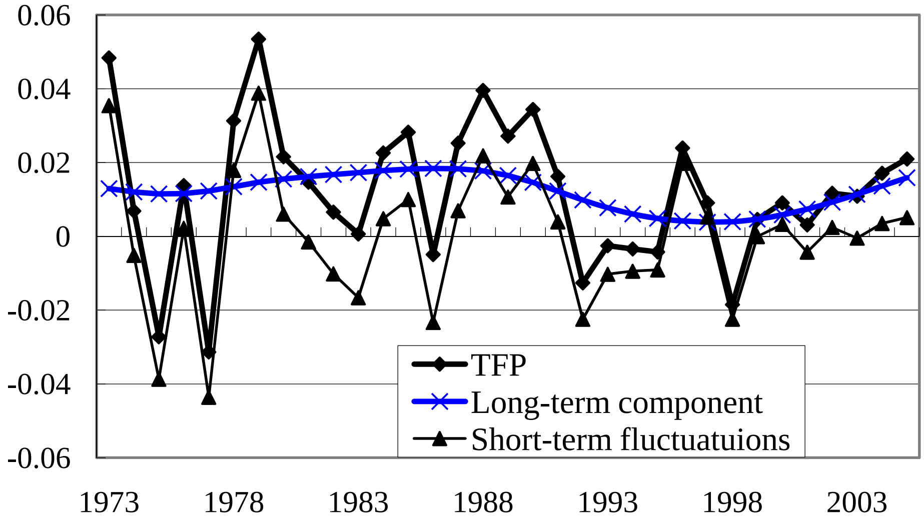


Figure 2-9 shows trends in the rate of increase in TFP and results for a decomposition of the data into long-term components and short-term fluctuations using an HP filter. Looking at changes in the long-term component, we see that from 1973 to the latter half of the 1980s, there was a stable fluctuation close to the 2% mark; in the 1990s there was a sudden decline, with the rate dropping to close to zero in the latter half of the 1990s, following which it began to climb again in the 2000s.

■Variables and unit root tests

(Verification of stationarity of variables)

Figure 2-10 shows a comparison of changes in the rate of increase in TFP in the JIP database and the rate of increase in MFP in the OECD data used in the previous section from 1985 onwards. Despite some discrepancy between the figures, increasing and decreasing trends correspond well, and no major differences can be observed.

Based on the hypotheses outlined in Section 1.2, the effect of the working population (LG) on the rate of increase in TFP (TFP) was considered using time series data for Japan*[12]. The level of economic openness (ROP) was employed as a control variable.

Figure 2-10 Comparison of JIP data and OECD data

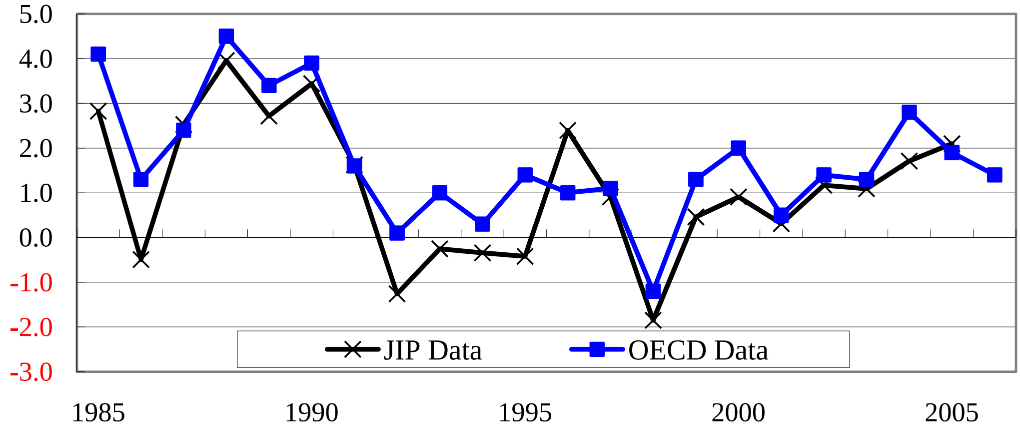


Figure 2-11 shows the results of tests of unit roots conducted to verify the stationarity of these three variables. In addition to these variables, other variables relating to age factors, for example the size of the working population aged 39 or below and its ratio to the total working population, were employed but significant results were not obtained. ADF, DF-GLS, and Ng-Perron tests were conducted for the unit roots. Despite the fact that rather vague results were obtained for the rate of increase in TFP, the null hypothesis that unit roots existed could not be discarded for any of the three variables*[13]. Based on this result, the analysis below will attempt to determine a cointegration relationship between the three variables, and if cointegration exists, will formulate a vector error correction model in order to seek the relationship between the variables.

Figure 2-11 Unit root tests

Estimation equation:
Constant term only

	ADF	DF-GLS	Ng-Perron
TFP	-2.571	-1.842	-0.929
lag orde	l=4	l=4	l=4
cv(5%)	-2.972	-1.953	-1.980
LG	-2.339	-0.789	-1.061
lag orde	l=1	l=2	l=2
cv(5%)	-2.954	-1.951	-1.980
ROP	-1.553	-1.487	-1.388
lag orde	l=0	l=0	l=0
cv(5%)	-2.954	-1.951	-1.980

Estimation equation:
Constant term +Time trend

	ADF	DF-GLS	Ng-Perron
TFP	-3.487	-3.929	-4.305
lag orde	l=4	l=4	l=4
cv(5%)	-3.581	-3.190	-2.910
LG	1.557	-0.850	-2.611
lag orde	l=0	l=1	l=1
cv(5%)	-3.553	-3.190	-2.910
ROP	-1.494	-1.597	-1.338
lag orde	l=0	l=0	l=0
cv(5%)	-3.553	-3.190	-2.910

Note: The lag order was selected using the Schwarz Information Criteria. The period for the tests was 1973-2005.

(2) Formulation of Cointegration Equation and Impulse Response Function

■Formulation of cointegration equation

(The possibility of a cointegration relationship could not be rejected, and a positive relationship exists between population and the rate of increase in TFP)

Johansen cointegration tests were conducted in order to determine the existence of a cointegration relationship between the rate of increase in TFP and the working population, and between the rate of increase in TFP, the working population, and the level of economic openness. The results are shown in Figure 2-12.

Figure 2-12 Results of Johansen maximum likelihood cointegration test

Number of cointegration vectors	Eigenvalue	Trace	5% C.V.	eigenvalue	5% C.V.
(TFP、LG)					
0	0.308	**20.99**	20.26	**11.04**	15.89
1	0.282	**9.95**	9.17	**9.95**	9.17
(TFP,LG,ROP)					
0	0.482	**36.41**	35.19	**19.75**	22.30
1	0.350	**16.66**	20.26	**12.93**	15.89
2	0.117	**3.73**	9.16	**3.73**	9.16

Note: The lag order (the order of VAR used in the maximum likelihood approach) was 2 in each case.

In the two-variable case (the combination of the rate of increase in TFP and LG), the test statistic in the trace test was 20.99, and the null hypothesis that no cointegration existed was rejected. However, the null hypothesis could not be rejected in the maximum eigenvalue test. In the three-variable case (the combination of the rate of increase in TFP, LG, and ROP), despite the fact that the trace test statistic, 36.41, indicated the existence of cointegration, the null hypothesis could similarly not be rejected in the maximum eigenvalue test. While some points remain vague in these results, they can be considered to indicate the existence of a cointegration relationship in both cases.

With the existence of cointegration as a precondition, the maximum-likelihood approach was employed to formulate cointegration equations, generating Equations (7) and (8) (figures in parentheses are t-values).

$$TFP = -1.254 + 0.113 \times LG \qquad (7)$$
$$(-1.90) \quad (1.89)$$

$$TFP = -2.762 + 0.240 \times LG + 0.469 \times RO \qquad (8)$$
$$(-3.32) \quad (3.29) \qquad (3.22)$$

In both Equations (7) and (8), the effect of the working population on the rate of increase in TFP is positive, and there is a positive relationship between the size of the working population and the rate of increase in TFP. The level of economic openness also has a positive effect on the rate of increase in TFP. These results are consistent with those obtained from the analysis using OECD panel data.

■Calculation of impulse response functions

(A shock to the population increases the rate of increase in TFP)

Based on Equations (7) and (8) above, vector error correction (VEC) models were formulated, and impulse response functions were calculated from the results. The results are shown in Figures 2-13 and 2-14. Generalized impulse response functions that were not sensitive to the order of the variables were determined.

Figure 2-13 shows the effect of a shock to the working population on the rate of increase in TFP based on a two-variable VEC model, and Figure 2-14 shows the effect of shocks to the working population and the level of economic openness on the rate of increase in TFP based on a three-variable VEC model. In both cases, a shock to the working population has a positive effect on the rate of increase in TFP. Figure 2-14 shows that while a shock to the level of economic openness has a negative impact on the rate of increase in TFP in the 3^{rd}year, the overall effect is positive.

When the effect of the size of the population (the working population) on technological progress (the rate of increase in TFP) is considered based on time series data for Japan, therefore, a positive relationship can be observed. This can be considered to support the hypothesis that the rate of increase in technological progress will become higher in proportion with the size of the population.

Figure 2-13 Impulse response of rate of increase in TFP (Two-variable VEC)

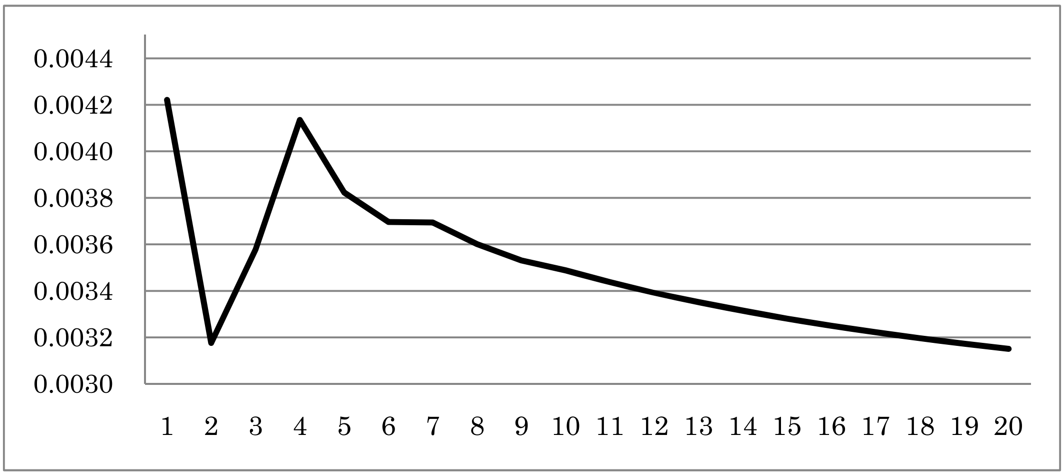
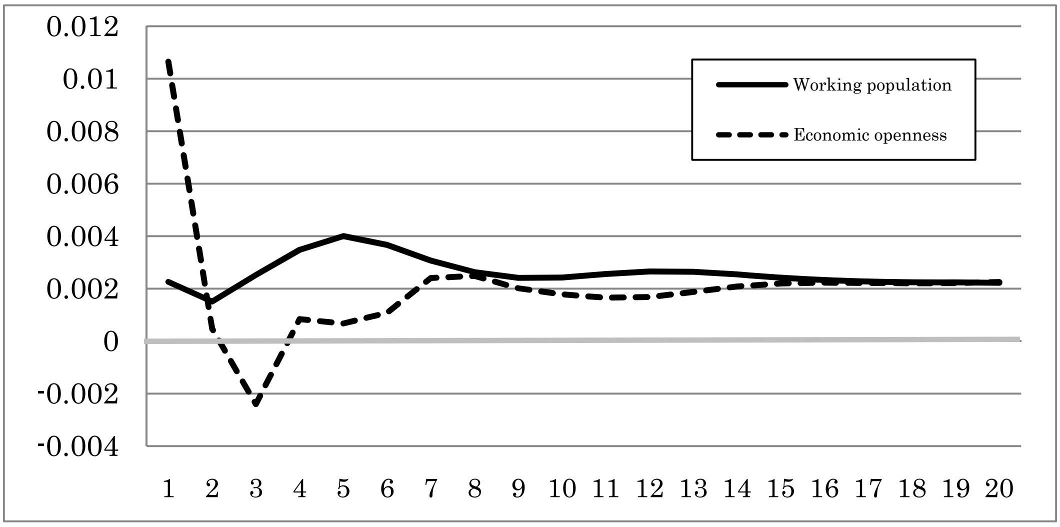


Figure 2-14 Impulse response of rate of increase in TFP (Three-variable VEC)



(3) Attempted Prediction of Future Trends

(TFP could grow at a rate of approximately 1% in the macroeconomy as a whole)

Japan's total population has begun to decline, and it is predicted that there will be a significant decline in the working population in future. According to the Employment Policy Workshop (2007), the present (2008) working population of 66.5 million will fall to 55.84 million in 2030 unless more women and elderly citizens participate in the labor market. However, even if more women and elderly citizens were to participate in the labor market, it is predicted that the working population would nevertheless decline to 61.8 million in 2030.

Under these circumstances, how can we expect the rate of increase in TFP to change in the future? To provide some indication, the author attempted to predict the rate of increase in TFP until 2030. Two methods were employed. The first of these was the extension of the three-variable (rate of increase in TFP, LG, and ROP) VEC model discussed above into the future. This method enabled the steady-state TFP growth rate to be calculated without formulating special scenarios for future exogenous variables. The second method involved the formulation of scenarios with the working population (LG) and the level of economic openness (ROP) as exogenous variables, using a cointegration equation (Equation (8)).

Figure 2-15 Projection of rate of increase in TFP until 2030 (VEC model)

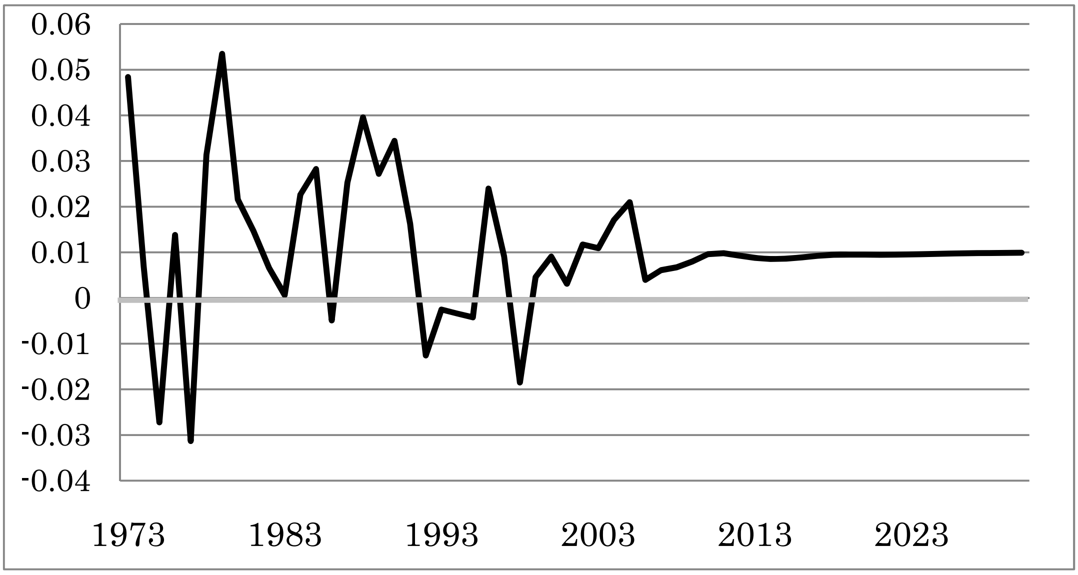


Figure 2-15 shows the results obtained by extending the VEC model into the future. According to these results, the rate of increase in TFP will stabilize at a basically steady level from 2010. A rate of increase of 0.95% was calculated for 2020 and a rate of 0.99% for 2030. The working population for 2030 calculated from the VEC model was 62.76 million, and the level of economic openness was 26.2%. Considered from a macroeconomic perspective, a base rate of growth of approximately 1% year-on-year can therefore be predicted.

For the second method, scenarios were formulated for the working population and the level of economic openness. The following three scenarios were formulated for the working population (for each case the annual average level of economic openness was the 2002-2007 average of 27.3%):

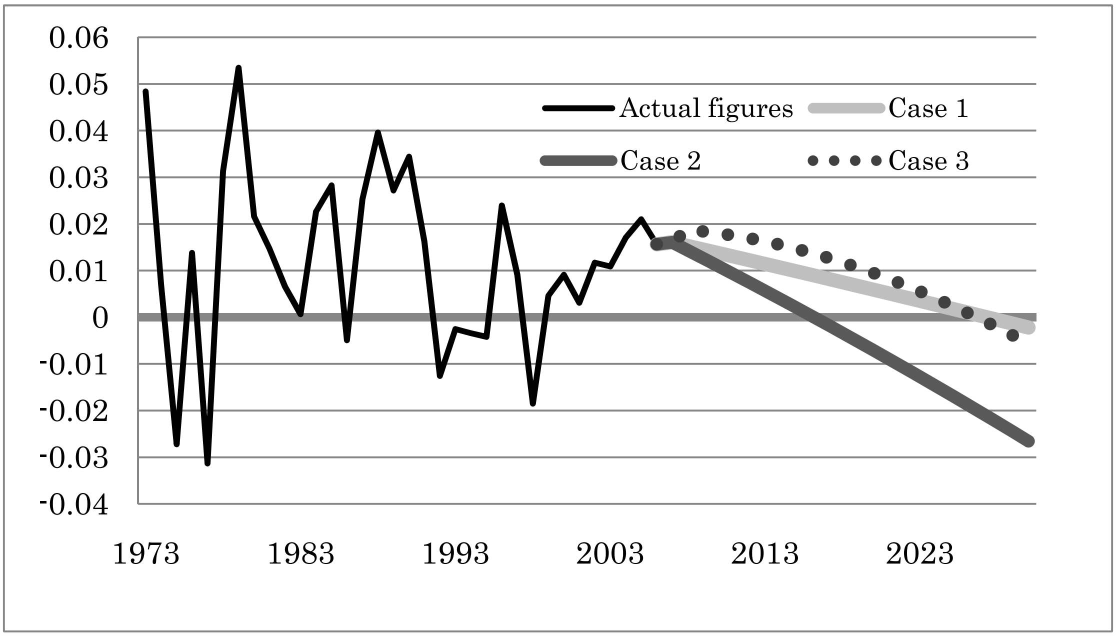
Case 1: Based on the projections of the Employment Policy Workshop (2007), the working population in 2030 was assumed to be 61.8 million (with increased labor market participation by women and elderly citizens), and was assumed to transition linearly from 2008 onwards.

Case 2: Based on the projections of the Employment Policy Workshop (2007), the working population in 2030 was assumed to be 55.84 million (without increased participation in the labor market by women and elderly citizens), and was assumed to transition linearly from 2008 onwards.

Case 3: The future working population was determined by multiplying the future population projections of the National Institute of Population and Social Security Research (median estimates) by the average rate of labor force participation from 1992 onwards. In this scenario, the working population in 2030 was 60.91 million.

Figure 2-16 shows the results of calculations based on these scenarios. For all cases, the rate of increase in TFP is negative at around 2030. A rate of increase of -0.2% was obtained for Case 1, in which the working population was highest. This was followed by -0.6% for Case 3, and -2.7% for Case 2, in which the decline in the working population was greatest.

Figure 2-16 Projection of rate of increase in TFP until 2030 (Exogenous model)



The fact that, based on a growth accounting perspective and assuming a decline in the working population and a slowing of capital stock accumulation, the future rate of increase in TFP becomes negative indicates a strong possibility that the potential GDP growth rate will also become negative. Growth strategies adopting medium- to long-term perspectives will become increasingly important.

5. Summary and Implication

The purpose of this paper has been to delineate the relationship between population and technological progress, and it has demonstrated a virtually exclusively positive relationship between the size of the population and the rate of technological progress (considered in terms of TFP and other measures). The relationship between population and technological progress has been extensively discussed, and has been the subject of a great deal of theoretical research, from Kuznetz (1960) to Kremer (1993) and Jones (2005). However, few attempts have been made to conduct empirical analyses focusing on the recent situation in advanced nations, and there is therefore significance in doing so.

Since the publication of Hayashi and Prescott (2002), there has been increased discussion concerning productivity and economic growth in Japan, resulting for example in the creation of the JIP database. However, research on productivity in Japan has focused on topics such as R&D and IT investment, and the relationship between productivity and the size of the population or population growth has been pushed to the side. The relationship between population and technological progress will presumably become a more important subject of research in future, when the nation's population commences a fully-fledged decline.

In addition, it is clear that technological progress does not depend exclusively on the size of the population or population growth. TFP, used here as a proxy variable for technological progress, is also affected by a variety of factors, including the measurement methods employed, the status of allocation of production factors, etc., and improvements in the quality of labor and capital stocks. When these points are considered, the treatment of technological progress in this paper can be seen to have been somewhat deficient. It will be necessary to give further consideration to this issue in future.

To conclude this paper, I would like to consider the implications of the empirical research conducted here for future sustainable growth in Japan.

If, as indicated up to this point, the size of the population and the size of the working population are essential elements in supporting technological progress, then a decline in population will result in a decline in the output of a potential engine of growth. Naturally, economic growth is not determined exclusively by technological progress, just as technological progress is not determined exclusively by the size of the population. However, measures will need to be put in place in order to maintain the potential for sustainable growth in Japan. Two policy orientations can be considered here.

The first of these is to boost the size of the population through family and population policies. Both policies to increase the birthrate and immigration policies may be considered. Policies to increase the birthrate are important, but taking into consideration the scale of their effect and the period required for that effect to be manifested (even if the birthrate returns to the necessary level, 20-25 years will be required before the effect is manifested in the market as an increased working population), they cannot be regarded as possessing immediate effectiveness. Immigration policies would supplement the shortfall in labor power with an influx of skilled workers from other countries, but it would be essential prior to their implementation to sufficiently study potential lifestyle and cultural issues in addition to the cases of advanced nations such as France and Germany, which have already adopted extensive immigration policies.

The second policy orientation that can be considered is to actively increase technological progress. This would naturally involve increasing education and training of skills, encompassing efforts to improve the quality of human capital, and at the same time it would be necessary to create an environment enabling a high level of intellectual exchange. The further advancement of globalization will promote intellectual exchange, and will also contribute to the dispersion of technologies. This is surely the time to seriously consider policies to boost technological progress by means of opening markets and promoting broad-ranging and large-scale exchanges of people and goods. It will be necessary to study this policy orientation in tandem with immigration policies.

[Notes]

*1 According to UN population projections published in 2006, the average annual rate of population increase from 2005 to 2050 will be -0.49% for Japan, against -0.16 for Italy, -0.24 for Germany, -0.27% for South Korea, 0.66% for the US, and 0.29% for the UK.

*2 See Kremer (1993), Barro and Sala-i-Martin (2003), and Jones (2005) for theoretical discussions.

*3 Below, the rate of increase in TFP (or MFP) is used for the rate of increase in technological progress. The rate of increase in TFP alone does not express the rate of increase in productivity. For further detail regarding these points, see Miyakawa (2006).

*4 MFP is formulated for the purpose of international comparison, and OECD statistical data cannot necessarily be considered the optimal basis for calculating MFP for individual nations.

*5 However, there is no significant difference with TFP figures calculated for Japan using JIP data, as discussed later in the paper.

*6 Because only the rate of increase in labor productivity is considered, there is no necessity to adjust the exchange rate, which frequently represents a problem in international comparisons.

*7 Given the significant differences in the populations of the countries compared, the effect for each country could not be sufficiently considered through the use of cross-sections and dummy variables alone, and the results of measurements using a fixed effects model were unstable. Because of this, a random effects model based on GLS estimates was employed.

*8 The ratio of investment to GDP was also considered, but significant results were not obtained.

*9 In addition to economic scale, whether or not figures were missing was also considered in the selection.

*10 Theoretical models generally do not distinguish between the total; population and the working population, but in actuality they differ in terms of size and rate of growth. In the case of Japan, the decline in the working population had already commenced from the latter half of the 1990s.

*11 The Japan Industrial Productivity (JIP) database is published as part of the “Study on Industry-Level and Firm-Level Productivity in Japan” of the Research Institute of Economy, Trade and Industry. The present study employed the JIP Database 2008.

*12 Converted to logarithms, as in the case of the analysis using OECD panel data.

*13 Variables displaying a one-stage difference were determined to be stationary.

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Chapter 3 Empirical Analysis of Relationship between Worker Age, Productivity, and Real Wages

Hiromichi Shirakawa

[Abstract]

This study analyzed the effect of the worker age structure and the average worker age on TFP (the rate of technological progress in the economy as a whole) and real wages. Plots of TFP and the wage rate against average worker age both display inverse U shapes with their peaks between average ages of 40 and 45. Beyond the mid-40s, TFP and real wages both decline, with the wage gradient steeper than that of TFP. The peak in the wage rate occurs approximately two years earlier than the peak in TFP. Future estimates of TFP and real wages based on this result indicated a strong possibility that despite the fact that TFP would peak in 2023 and thereafter decline, the ratio of labor costs to GDP would decline. These results can be considered to demonstrate that the aging of society will not have a profoundly negative effect from the perspective of productivity and of costs. It will be important in the future to direct the “bonus” produced by the aging of society from changes in TFP and real wages towards the employment of young people and investment in research and development

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1. Problem and Approach

(1) Problem and research orientation

Japanese society is aging, and population decline as a result of the nation’s low birthrate has already commenced. What effect will these demographic trends − a low birth rate, the aging of society, and population decline − have on the Japanese economy?

The majority of analysts and market participants appear to believe that the aging of Japanese society will further weaken the fundamentals of the nation’s economy. Pessimistic commentators predict a dark future for Japan’s economy and markets, with an increasing deficit, declining household savings, loss of the trade surplus, significant interest rate increases, and a declining exchange rate.

However, it is important that we do not restrict ourselves to analyzing the impact of the process of the aging of society on the nominal variables of the economy and markets, but also focus on the real variables represented by productivity and real wages. This is because there is a possibility that the distribution of income in the Japanese economy (the distribution of income between the corporate and household sectors) will change significantly if the aging of society exerts different effects on productivity and wages (real wages).

The important point is that it is clear that if there is a change in the distribution of income, there will be changes in the trends of corporate capital spending and productivity, and as a result there will be a change in the potential growth rate of the Japanese economy. In other words, many dynamics analyses predicated on the concept that there will be no change in the potential growth rate could be rendered meaningless.

Based on this view of the issue, this chapter will consider the relationship between worker age, productivity, and wages (real wages) in the Japanese economy from a variety of perspectives, and will attempt to project the effect of the progressive aging of Japanese society on the future course of productivity, wages, and corporate income.

(2) Previous research on the relationship between worker age and productivity

A certain amount of research has been conducted outside Japan regarding the relationship between worker age and productivity, but the type of productivity focused on differs with the data employed in the analysis. It tends to be the case that when data concerning individual workers is employed, work performance (for which indexes have been formulated) is the subject of the analysis, when workplace data is employed it is labor productivity, and when macro-economic data is employed, it is total factor productivity (TFP)*1.

The interesting point here is that despite the different types of productivity focused on as a result of the type of data employed, it is generally the case that the analyses find that when plotted, the relationship between worker age and productivity describes an inverse U, and that productivity peaks when workers are in their 40s. This point is made clear in Prskawetz, et al (2006), a survey of empirical analyses of the relationship between worker age and productivity.

Skirbekk (2008) presents an analysis which finds that productivity reaches its peak in workers' 40s using data for individual workers. Using the results of psychological research, this study formulated indexes of the productivity of individual workers based on a variety of work performance-related data, including the results of U.S. job performance tests and intelligence tests, and produced worker age and productivity curves. The results indicated an inverse U relationship between the age and productivity of individual workers, with productivity peaking between the ages of 35 and 45. To explain the inverse U relationship, the study indicated the possibility of the coexistence of abilities that increase with advancing age (vocabulary, work organization ability, etc.) and abilities that decline with increasing age (strength, memory, numerical ability, etc.).

Malmberg, et al (2008) conducted research on productivity at the workplace level. Using panel data for value-added productivity and worker attributes (personality) in Swedish workplaces, this study analyzed the relationship between the worker age structure and labor productivity. Dividing worker age groups into 29 and below, 30-49, and 50 and above, the study found that workplace productivity tended to reach its highest level when the ratio of workers aged 30-49 increased. Kawaguchi, et al (2006) conducted similar research concerning blue collar workers in the Japanese manufacturing industry. Conducting a panel analysis on data from the Survey of Industry Statistics and the Basic Survey on the Wage Structure, this study found that the relationship between years of work experience and labor productivity described an inverse U shape, and that labor productivity peaked at approximately 20 years of work experience (around the age of 40).

Feyrer (2008) analyzed the relationship between worker age and TFP using macro-economic data. Using OECD cross-country panel data, this study regressed changes in TFP on the age structure, grouped into ten-year units. The results showed that the rate of growth of TFP tended to reach its highest level when the ratio of workers in their 40s increased. Werding (2008) analyzed the relationship between the worker age structure and TFP using large-scale cross-country panel data for advanced and developing nations. This study found that there was an inverse U relationship between worker age and TFP, and that the rate of growth of TFP was highest in those countries in which the ratio of workers in their 40s had increased.

(3) Approach adopted and data used in the present paper

As indicated above, previous research suggests that productivity at both the micro-economic and macro-economic levels tends to reach its peak for individual workers in their 40s and for an average worker age in the 40s.

Based on the results of this previous research, this paper will analyze the relationship between productivity and worker age in Japan, focusing on TFP. TFP has been chosen as the focus of the analysis because I seek to obtain an image of the future course of the trend growth rate of the Japanese economy based on a growth accounting perspective.

TFP is understood to provide a measure of the efficiency with which all factors of production (capital, labor, raw materials, etc.) are deployed, i.e., as a measure that expresses the capacity for technological innovation. It can be conjectured that a fixed relationship exists between worker age and the capacity for technological innovation in the economy, or the economy's potential for growth, because there is some relationship between the work performance, technical ability, and age of individual workers, or there is some relationship between the average age of workers or the worker age structure and the capacity for technological innovation in the economy as a whole. However, the present paper will not delve too deeply into the theoretical basis of the relationship between worker age and TFP.

In addition to TFP, this paper will analyze the relationship between wages (real wages) and worker age. There is no theoretical basis for the assertion that a stable relationship exists between macro-economic productivity in the form of TFP and real wages. This is because there is no necessity for the "fruits" of the capacity for technological innovation − economic growth and increased corporate profits − to be distributed only to workers. The reason that this paper will nevertheless analyze the relationship between worker age and real wages is that if the ongoing aging of Japanese society has a differing impact on TFP and real wages, it is possible that there will be a significant change in the share of corporate profits and worker recompense in GDP.

The data concerning TFP, real wages, and worker age in the following empirical analysis is sourced from the JIP Database created by the Research Institute of Economy, Trade and Industry*[2].

First, TFP was calculated independently of the JIP Database. The JIP Database formulates labor service input indices and capital service input indices that consider labor quality and capital quality, and subtract the contribution to growth of these indices from real value-added growth to calculate TFP. When this method is used, part of the relationship between age and productivity is incorporated in labor quality*3, but it is not incorporated in TFP. In order to resolve this issue, the present paper will define TFP as the contribution of man hour labor input and real capital stock subtracted from the real growth rate. Further details can be found in Section (1) of the Appendix.

To obtain real wages, the nominal labor costs by industry in the JIP Database have been divided by the sum of the number of workers by industry and GDP deflators, giving the real labor cost per worker. The calculation of the nominal labor costs by industry in the JIP Database uses wages classified by worker attributes (sex / level of academic achievement / age / job position), based on information obtained from the Basic Survey on the Wage Structure and the

Basic Survey on the Employment Structure, and they therefore do not correspond to SNA-based wages.

Average worker ages are weighted averages found by multiplying the number of workers in each age five-year age group by the median figure for that age group.

2. Formulation of Productivity Curves and Real Wages Curves

(1) Empirical analysis of the age structure ratio (elasticity analysis using linear panel model)

First, an analysis was conducted in which TFP was regressed on the proportion of workers in different age groups, following the method used by Feyrer (2008). Panel data for 106 industries drawn from the JIP Database was employed. The sample period was the 34-year period from 1973 to 2006. TFP was indexed with figures for 1973 defined as 100 for each industry. 10-year worker age groups were used. When five-year age groups were used, the existence of the baby boom generation skewed the composition of the age structure (Figure 3-1), generating issues of reliability. The model was formulated as shown below. Here, “log” refers to natural logarithms.

$$\log(Y_{i,t}) = \alpha_i + \sum_{h}^{H} \beta_h \log(x_{h,i,t}) + \varepsilon_{i,t} \quad (1)$$

$Y_{i,t} \in (TFP_{i,t}, LC_{i,t})$: TFP or real wages for industry *i* at time *t*

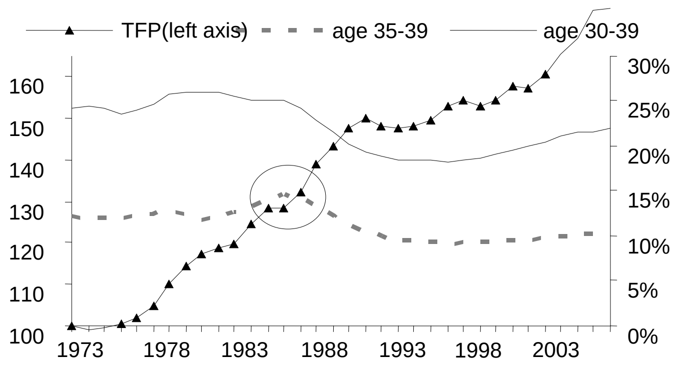
α_i : Individual industry effect

$x_{h,i,t}$: Proportion of workers in age group *h*; $h \in$(20s, 30s, 40s, 50s, 60s)

β_h : Parameters to be calculated

$\varepsilon_{i,t}$: Error term

Figure 3-1. Changes in TFP and age ratio
(5-year groups vs. 10-year groups)



Source: JIP Database, RIETI
Calculation: Credit Suisse

A first difference was taken, and the following model, which excludes the effect of each industry, was employed in the actual calculations. The proportion of workers in their teens was taken as the benchmark, and the coefficient for this group was set at 0.

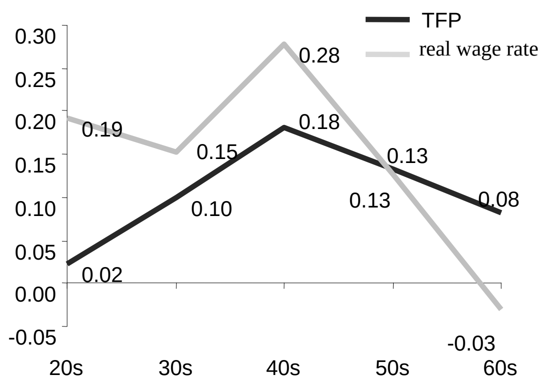
$$\Delta \log(Y_{i,t}) = \sum_{h}^{H} \beta_h \Delta \log(x_{h,i,t}) + \varepsilon_{i,t} \quad (2)$$

Figures 3-2 and 3-3 show the results of least squares estimation for the model. The coefficients calculated for each age group show the percentage increases in TFP and real wages when the proportion of workers in that age group increases by 1% against the proportion of workers in their teens.

The results of this analysis demonstrate the following:

- The regression coefficients were lower in the case of both TFP and real wages for workers in their 20s, 30s, 50s, and 60s than for workers in their 40s. This is to say that TFP and real wages will each be most prone to increase when there is an increase in the number of workers in their 40s.
- When results were plotted with worker age composition on the horizontal axis and TFP and real wages on the vertical axis, both TFP and real wages described inverse U shapes with their vertices occurring for workers aged in their 40s.
- Real wages were more sensitive to changes in age groups than TFP. The gradients of real wages curves from the 30s to the 40s, and from the 40s to the 60s, are therefore steeper than the gradients of TFP curves.

Figure 3-2. Results for linear panel model (Equation 2) (Elasticity)



Source: JIP Database, RIETI
Calculation: Credit Suisse

Figure 3-3. Results for linear panel model (Equation 2) (Elasticity)

	TFP		Real wage	
	Calculated value	t value	Calculated value	t value
20s	0.02	1.59	0.19	6.33
30s	0.10	2.67	0.15	5.00
40s	0.18	5.02	0.28	9.43
50s	0.13	4.05	0.13	4.27
60s	0.08	3.05	-0.03	-1.76

Source: JIP Database, RIETI
Calculation: Credit Suisse

These results match the results obtained by Feyrer (2008) and Werding (2008). They indicate the possibility that in Japan also, there is an inverse U relationship between worker age (age structure) and TFP, and that TFP reaches its highest level when workers are aged in their 40s. The results also show that there is an inverse U relationship between real wages and worker age, and that TFP reaches its peak for workers in their 40s. The elasticity of real wages with regard to the proportion of workers in different age groups is greater than that of TFP, and the rate of decline in real wages when age increases is greater than that of TFP.

(2) Empirical analysis of average age (Formulation of curves using nonlinear panel model)

As the previous section demonstrated, it is highly possible that the relationship between worker age, TFP, and real wages is a nonlinear relationship. Based on this possibility, nonlinear curves were directly formulated for the relationship between average worker age and TFP, and between average worker age and real wages. An econometric explanation of the method used can be found in Appendix 2.

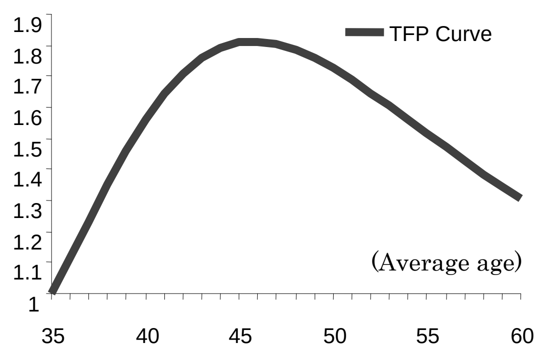
Results of calculation of TFP curves (Average worker age / TFP curve)

This section will discuss the results obtained using a fixed effects model employing inverse Weibull coefficients, which was most suited to this case.

Figure 3-4 shows a curve plotted using functions calculated for the entire sample (panel data). This can be considered to be the theoretical relationship between average worker age and TFP for the entire sample. Figure 3-5 shows curves for individual industries (106 curves) generated by applying this theoretical curve to data for individual industries. Overall, the functions seem to display a relatively good fit.

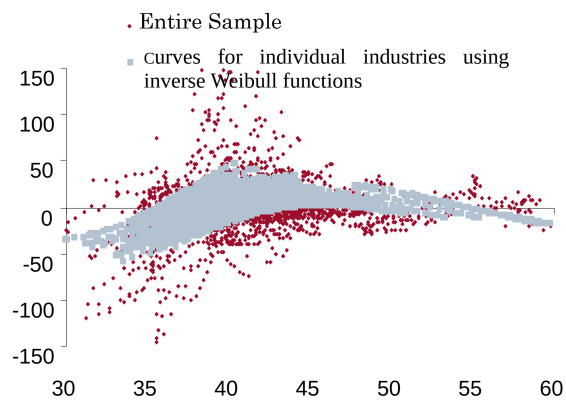
Based on the calculated curves, TFP reaches its peak at an average worker age of 45.8, following which it gradually declines. The gradient of the decline in TFP following 45.8 is milder than that of the gradient of the increase in TFP from 35 to 45.8. In fact, when changes in the elasticity of TFP with regard to average worker age is considered, we find that the average elasticity as TFP is increasing is +2.24 and the average elasticity when TFP is decreasing is -0.62 (the maximum value for elasticity with regard to average worker age when TFP is increasing is +3.56 for age 35.6, and the minimum value for elasticity when TFP is decreasing is -1.79 for age 60). The form of this TFP curve indicates the possibility that TFP will not decline radically even as the aging of Japanese society progresses.

Figure 3-4. Theoretical values for inverse Weibull distribution for TFP; fixed effects model



(Theoretical model values with values for 35 as benchmark)
Source: JIP Database, RIETI
Calculations: Credit Suisse

Figure 3-5. Fit of inverse Weibull distribution for TFP; fixed effects model



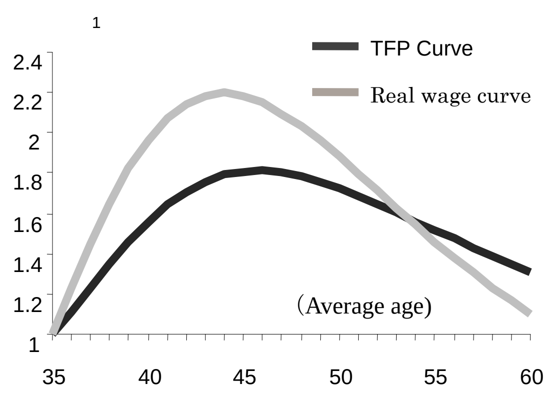
Source: JIP Database, RIETI
Calculations: Credit Suisse

■ Results of calculation of real wages curves (Average worker age / real wages curves)

The use of inverse Weibull functions also displayed the best performance in the case of real wages curves, and as shown in Figure 3-7, resulted in a good fit for the entire sample. Based on the calculated curve, real wages reach their peak at an average worker age of 43.9, approximately two years before 45.8, the age at which TFP reaches its peak.

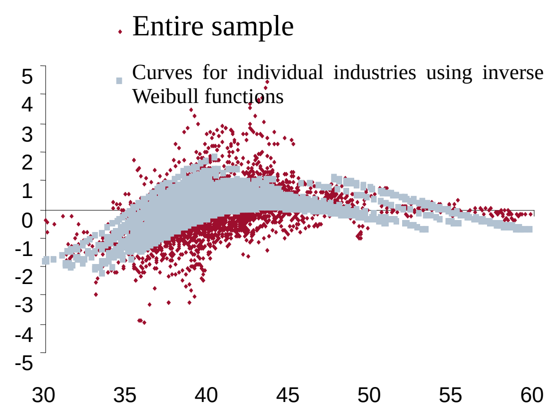
As in the case of TFP, after an average worker age of 43.9 is exceeded, real wages display a gradual decline. The pace of this decline when the peak has been passed is faster for real wages than for TFP. The average elasticity of real wages with regard to average worker age is +5.44 when real wages are increasing, and is -2.30 when real wages are declining. The gradients of the increase and of the decline are both comparatively steep. This is indicated visually in Figure 3-6, which shows both the real wages curve and the TFP curve. This suggests the possibility that as the aging of Japanese society proceeds, real wages may decline more sharply than TFP.

Figure 3-6. Theoretical values for inverse Weibull distribution for real wages; fixed effects model



(Theoretical model values with values for 35 as benchmark)
Source: JIP Database, RIETI
Calculations: Credit Suisse Source: JIP Database, RIETI
Calculations: Credit Suisse

Figure 3-7. Fit of inverse Weibull distribution for real wages; fixed effects model



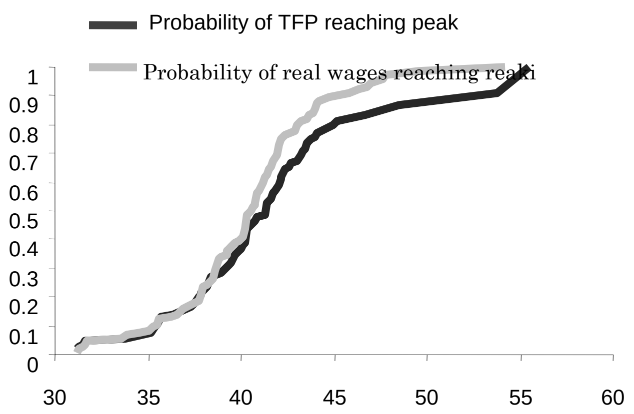
Source: JIP Database, RIETI
Calculations: Credit Suisse

(3) Accuracy of calculated ages for peaks of TFP and real wages

As indicated above, the formulation of nonlinear curves showed that real wages reach their peak at an average worker age approximately two years younger than the age for peak TFP, and that the pace of the decline in real wages following this peak is more rapid than for TFP. Given that the former result will have a decisive effect on the difference in the trajectories of TFP and real wages in the next five-to-ten-year period, it was considered desirable to subject it to a more rigorous examination.

A duration analysis[*4] was conducted in order to estimate the probability of TFP and real wages reaching their peak for each age group, and it was discovered that statistically significant differences existed in the calculated probabilities. The results showed that the average age for the peak in real wages displayed a lower level of significance than the average age for the peak in TFP (1 percent significance criterion)[*5]. Figure 3-8 shows the estimated probabilities of TFP and real wages reaching peaks for each age group considered.

Figure 3-8. Probability of TFP and real wages reaching peaks



Source: JIP Database, RIETI
Calculations: Credit Suisse

(4) Summary of empirical analyses

Empirical analyses of the relationship between the average age of workers, TFP, and real wages using data classified by industry from the JIP Database for the period 1973-2006, indicated the following:

・ A linear model analysis of the relationship between the worker age structure, TFP, and real wages showed that TFP and real wages both displayed the greatest tendency to increase when the proportion of workers in their 40s increased, and that real wages were more sensitive than TFP to changes in the worker age structure.

- A nonlinear model analysis of the relationship between the worker age structure, TFP, and real wages showed that the TFP curve and the real wages curve each reach their peaks when workers are in their 40s, but real wages reach their peak at an age approximately two years younger than the age for the peak in TFP. Statistical examination of this difference in peak ages showed it to be significant. In addition, a comparison of the forms of the curves showed the gradient of the real wages curve to be steeper than that of the TFP curve, both when increasing and when declining.
- These observations indicate the strong possibility that the ongoing aging of Japanese society will result in long-term declines in TFP and real wages, but also suggest that real wages will begin to decline earlier, and the pace of their decline will be more rapid.

3. Future Outlook for TFP and Real Wages

Next, the future course of TFP and real wages was simulated. For this simulation, 1) the future average worker age was estimated based on estimates of the future population by age group published by the National Institute of Social Security and Population Research (assuming no change in 2008 figures for employment rate by age group), and 2) future values for TFP and real wages were estimated using inverse Weibull functions and fixed effects models, which can be considered to display the greatest reliability.

The following observations can be made with regard to the future course of the estimated average worker age and the corresponding TFP and real wages. (The median birthrate was used as the birthrate condition for estimation of future population).

1) The average worker age, 44.03 in 2006, will begin to increase. By 2030, a period of slightly more than 20 years, the average age of workers will increase by approximately 2.5 years. However, the effect of the retirement of the so-called second baby boom generation around 2040 will slow the pace of this increase. Because of this, the increase in the average age of workers will slow to approximately 1.2 years in the 20-year period between 2030 and 2050 (Figure 3-9).
2) Because the average worker age for peak TFP is relatively high and the pace of increase in the average worker age will slow from around 2040, it is projected that figures for TFP in 2050 will be virtually identical to 2006 figures. If 2006 figures are indexed as 100, the index in 2050 will be 100.03. TFP will gradually increase until 2023, when the average age of

workers reaches 45.8, the age at which TFP is at its peak. It can therefore be indicated that the aging of Japanese society will have a limited impact on the productivity of the economy, measured as TFP, in the medium- to long-term.

3) By contrast, because the average worker age at which real wages reach their peak, 43.9, is slightly lower than the actual average worker age in 2006, 44.03, real wages can be considered to have entered a phase of decline at some stage in 2005. Because of this, if 2006 figures for real wages are indexed as 100, the index will decline to 98.14 in 2023, the year when TFP reaches its peak. Following this, the decline will increase in pace until the mid-2030s, and the index will reach 93.64, a decline of more than 6% against the 2006 figure, in 2050 (Figures 3-9, 3-10).

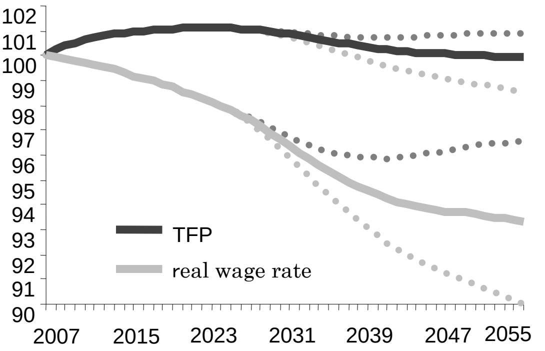
4) As this indicates, the future trend of real wages will be quite different to the future trend of TFP. This difference can be easily visualized using a graph that plots year-on-year changes (Figure 3-11).

Figure 3-9. Future estimates of TFP and real wages

	TFP	Real wage	Average worker age
2006	100.00	100.00	44.03
2010	100.64	99.72	44.62
2015	100.97	99.19	45.13
2020	101.10	98.56	45.56
2023	101.11	98.14	45.80
2025	101.10	97.79	45.98
2030	100.92	96.63	46.52
2035	100.60	95.36	47.02
2040	100.30	94.41	47.37
2045	100.11	93.87	47.55
2050	100.03	93.64	47.63
2055	99.91	93.32	47.74

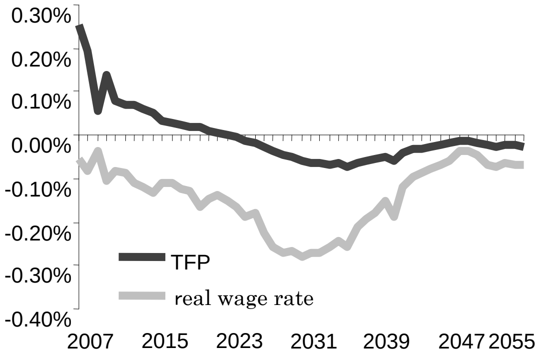
Source: JIP Database, RIETI
Calculations: Credit Suisse

Figure 3-10. Future estimates of TFP and real wages (2006 = 100)



Notes: The dotted lines in the upper part of the graph show projected figures based on a high birthrate scenario, and the dotted lines in the lower part of the graph show projected figures based on a low birthrate scenario.
Source: JIP Database, RIETI; National Institute of Population and Social Security Research; Ministry of Internal Affairs and Communications
Calculations: Credit Suisse

Figure 3-11. Future estimates of TFP and real wages (Year-on-year changes)



Source: JIP Database, RIETI; National Institute of Population and Social Security Research: Ministry of Internal Affairs and Communications
Calculations: Credit Suisse

4. Future Trends of Ratio of Labor Costs to GDP

As indicated in the preceding section, a consideration of the future trajectories of TFP and real wages shows that while the former will remain largely unchanged against 2006 figures in 2050, the latter will decline by more than 6%. This difference between the two reflects the facts that the average age of the working population at which TFP reaches its peak is two years greater than the average age at which real wages reach their peak, and that the rate of decline following the peak is greater in the case of real wages.

It does not need to be restated that the reliability of this projected difference in the future trends of TFP and real wages is dependent on the reliability of the projected TFP curve and real wages curve. However, given that 1) the results of a duration analysis demonstrate that the difference between TFP and real wages in terms of peak ages is statistically significant, and 2) the fact that the rate of decline following the peak is greater in the case of real wages is confirmed by calculating functions other than the inverse Weibull functions (specifically, Mincer functions) used in this report (see Appendix 2), the fact that there will be a difference in the future trend of the two variables can be considered a reliable conclusion.

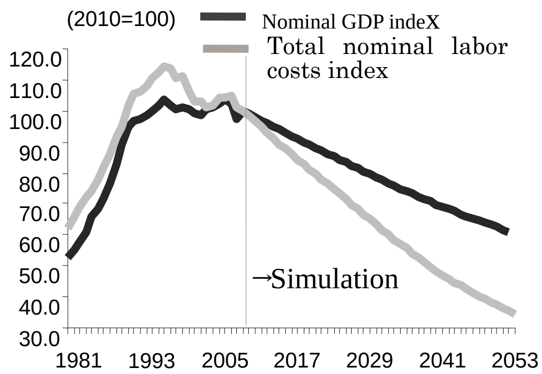
The remainder of this section will attempt to simulate the effect of this difference in the future trend of TFP and real wages on the future trend of the ratio of labor cost to GDP based on this assumption. The future course of nominal GDP and labor costs, and therefore of the ratio of labor costs to GDP, can be simulated on the basis of future projections for TFP, real wages, and the working population, using fixed preconditions for the rate of price fluctuation, working hours, and capital investment. The results of such a simulation would present suggestive implications with regard to the way in which the ongoing aging of Japanese society will change the future course of the allocation of income in the nation's economy.

Intuitively, we may state that there is a strong possibility that the aging of society will tend to reduce the ratio of labor costs to GDP (which can be considered as a type of measure of labor's share). The results of the simulation accorded with this intuition. The procedures employed in the simulation and the results obtained were as follows:

1) The future course of nominal GDP was considered to be determined by the future course of real GDP and GDP deflators, and the future course of real GDP was considered to be dependent on the future course of TFP. It was assumed that the 1998-2008 average growth rate of GDP deflators (-1.1%) would continue into the future. Nominal GDP was assumed to decline at an annual average of a little more than 1% (1.1%) from 2011 to 2055. Credit Suisse projections were employed for nominal GDP for 2009 and 2010; simulation figures were used from 2011.
2) The assumption that real GDP is dependent on TFP is equivalent to assuming that the contribution of labor input and capital input essentially cancel each other out. This assumes that the reduction in labor input due to the aging of society will be canceled by an increase in capital input. Broadly speaking, the concept is that the reduction in human capital due to the aging of society will to some extent demand a substitutive capital input from the government and companies.
3) With regard to the future trend of nominal labor costs, the future rate of decline in the number of workers based on Population Projections for Japan, 2006-2055 (assuming no change in the age composition of the workforce against 2008 figures) was subtracted from nominal wages, found by adding future projections for GDP deflators (an average annual growth rate of -1.1%) to future projections for real wages. Total nominal labor costs were assumed to decline at an average annual rate of 2.3% from 2011 to 2055. Data for total nominal labor costs can only be obtained from the JIP Database up to 2006. For 2007-2010, estimated figures based on actual figures and projections for nominal compensation for workers were employed; simulation figures were employed from 2011).

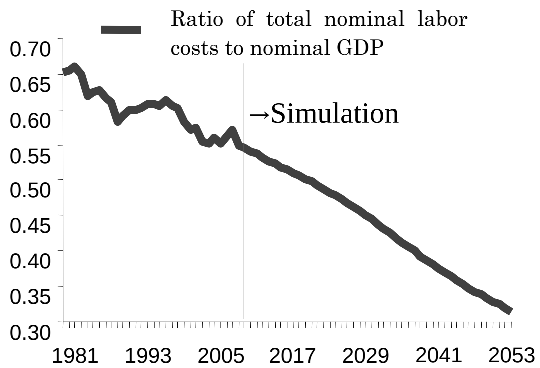
4) In this manner, when the difference in the future courses of TFP and real wages are reflected, a difference in the future courses of nominal GDP and nominal total labor cost is also revealed. Nominal GDP and nominal total labor costs both decline, but the rate of this decline is slower in the case of the nominal GDP (Figure 3-12). Because of this, the ratio of nominal total labor costs to nominal GDP declines continuously. According to the simulation, the actual 2006 figure of approximately 56%, estimated to reach approximately 57% in 2009, will decline to less than 51% in 2020 and to approximately 32% by 2055 (Figure 3-13).

Figure 3-12. Change in nominal GDP and total labor costs



Note: The figure for gross value-added for calendar year 2009 is a Credit Suisse estimate
Source: JIP Database, RIETI; National Institute of Population and Social Security Research; Cabinet Office
Calculations: Credit Suisse

Figure 3-13. Change in ratio of labor costs to nominal gross value-added



Source: JIP Database, RIETI; National Institute of Population and Social Security Research: Cabinet Office
Calculations: Credit Suisse

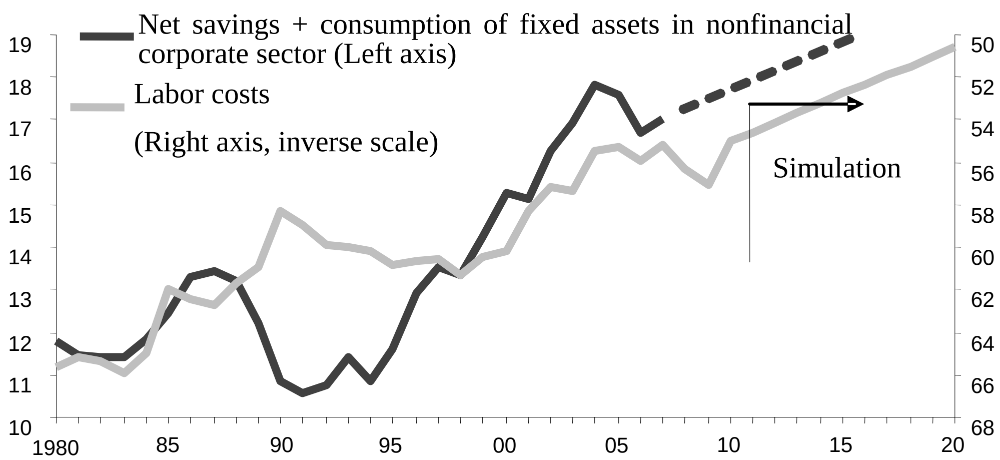
5. Conclusion

When the aging of society is considered as an increase in the average age of the working population, future projections see both productivity measured as TFP and real wages declining in the Japanese economy. However, the average worker age for peak TFP is 45.8, approximately two years in advance of the average age for the peak in real wages. Because the average age of the working population in Japan at present is a little over 44, if all other conditions remain the same, TFP will continue to increase until 2023. By contrast, the average worker age for peak real wages has already been exceeded, and it is likely that real wages will begin to decline from this point onwards. The rate of decline will be higher in the case of real wages than TFP.

Because of this, there is a strong possibility that as the aging of Japanese society proceeds, the ratio of total labor costs to GDP (or labor's share) will decline, and that there will be a consequent increase in the ratio of corporate income to GDP. In this sense, the aging of Japanese society will represent a transfer of income from households to companies. However, if companies actively invest this "bonus" from the aging of society in employing young people and conducting research and development, the future decline in productivity can be mitigated.

A more important point is that while it is very likely that the aging of society will reduce household savings, it is also quite possible that it will increase corporate savings. The total of net savings and consumption of fixed capital (for the nonfinancial corporate sector), a proxy variable for corporate savings, displays a stable inverse correlation to total nominal labor costs. The simulation conducted in this study indicates that if the ratio of total nominal labor costs to GDP trends downward, the ratio of corporate savings to GDP will trend upward (Figure 3-14). This suggests that even as Japanese society ages, the IS balance of the economy will not easily tip towards excess investment, and consequently the balance of payments will not easily tend towards deficit.

Figure 3-14. Ratios of corporate savings and total nominal labor costs to GDP



Source: Cabinet Office
Calculations: Credit Suisse

[Notes]

*1 A measure of how efficiently total production factors (labor, capital, raw materials) are employed. Defined as “Productivity per unit for all production factors (labor, capital, and raw materials) combined” (Fukao and Miyakawa (2008)). In terms of treatment using production functions, generally treated as a residual. TFP is also considered as representing the capacity for technological innovation in the economy as a whole.

*2 The Japan Industry Productivity (JIP) Database was formulated by RIETI using data classified by industry to enable growth accounting analyses. The database contains data for 108 industries covering the period 1973-2006. The present report used data for 106 industries, excluding the classifications “Housing” (a sector in which value-added corresponds to imputed rent) and “Activities Not Elsewhere Classified.” The total number of samples was 3,604 (106 industries X 34 years).

*3 The labor input indices in the JIP Database are weighted aggregates of man hour input by worker attribute, weighted for the differences in wages for different worker attributes (sex, age, academic achievement, job position). Labor quality is defined as the difference between the rates of growth of labor input indices and man hour labor input indices. For more information, see Fukao and Miyakawa (2008), pp. 85-105.

*4 Duration analyses, or survival assays, are chiefly used in medical fields, for example to determine whether there is any difference in the period of survival of patients who receive a specific treatment and those who do not. In economics, the method is used to analyze the expansion or contraction of the economy across a continuous duration. In the analysis conducted here, the period for which TFP or real wages continue to increase for a specific average worker age is considered a continuous duration. An HP filter was used to determine the trend, and a non-parametric estimation method (the Kaplan-Maier method) which is not dependent on specific probability functions was employed. The probability of the occurrence of peaks shown in Figure 3-8 is defined as the estimated probability subtracted from 1.

*5 A log-rank test of the difference in the Kaplan-Meier curves in Figure 3-8 produced a p value of 0.0077; a statistically significant (1% level) difference was determined between the Kaplan-Meier curves for TFP and real wages.

[References]

in Japanese

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Appendices

(1) Growth accounting and TFP in the JIP Database

Growth in value-added in the economy is expressed as the sum of the contribution of labor and capital input and the increase in total factor productivity (TFP). Growth accounting is an approach that seeks to understand economic growth by breaking it down into these three factors. TFP is defined as the figure obtained by subtracting the contributions of labor services input, L, and capital services input, K, from value-added, Y. The JIP Database created by RIETI employs the growth accounting approach. Breaking the entire Japanese economy down into 108 detailed industry sectors, it records annual data for each sector including gross productivity and intermediate inputs, capital stock and capital cost by asset, and labor input by worker attribute. The explanation of the growth accounting methodology used for each sector in the JIP database offered here follows that provided by Fukao and Miyagawa (2008).

First, linear homogeneous productivity functions are consecutively formulated for intermediate inputs X, labor L, and capital K. T expresses the level of productivity.

$$Q(t) = F\left(X(t), L(t), K(t), T(t)\right) \qquad (1)$$

(t), which expresses the fact that the parameter is a time function, is omitted below. Based on Euler’s theorem regarding homogeneous functions, Equation (1) can be transformed as follows:

$$Q = \frac{\partial F}{\partial X} X + \frac{\partial F}{\partial L} L + \frac{\partial F}{\partial K} K \qquad (2)$$

Taking natural logarithms for both sides of Equation (2) and differentiating, the following equation is obtained:

$$\frac{\dot{Q}}{Q} = \frac{\frac{\partial F}{\partial X} X}{Q} \frac{\dot{X}}{X} + \frac{\frac{\partial F}{\partial L} L}{Q} \frac{\dot{L}}{L} + \frac{\frac{\partial F}{\partial K} K}{Q} \frac{\dot{K}}{K} + \frac{T\dot{F}P}{TFP} \qquad (3)$$

TFP/TFP is defined as follows using the rate of increase in TFP:

$$\frac{T\dot{F}P}{TFP} = \frac{\frac{\partial F}{\partial T} T}{Q} \frac{\dot{T}}{T}$$

Assuming that each company behaves as a price taker in the production factors market, the following equation can be obtained from the first-order condition of the cost minimization problem ($p_x X + wL + rK$):

$$\lambda = \frac{p_x}{\frac{\partial F}{\partial X}} = \frac{w}{\frac{\partial F}{\partial L}} = \frac{r}{\frac{\partial F}{\partial K}} \tag{4}$$

λ : Limit cost (Lagrange multiplier of cost minimization problem)

p_x : Price of intermediate inputs

w : Wage rate

r : Capital cost

The following equation is obtained by substituting Equation (4) in Equation (2):

$$\lambda Q = p_x X + wL + rK \tag{5}$$

The following equation is obtained when Equation (4) is substituted in Equation (3):

$$\frac{T\dot{F}P}{TFP} = \frac{\dot{Q}}{Q} - \frac{p_X X}{\lambda Q}\frac{\dot{X}}{X} - \frac{wL}{\lambda Q}\frac{\dot{L}}{L} - \frac{rK}{\lambda Q}\frac{\dot{K}}{K} \tag{6}$$

Because, from Equation (5), the term that is multiplied by the rate of change of each variable can be rewritten as the following cost share

$$\frac{p_x X}{\lambda Q} = \frac{p_x X}{p_x X + wL + rK} \tag{7}$$

Equation (6) can be expressed as follows

$$\frac{T\dot{F}P}{TFP} = \frac{\dot{Q}}{Q} - v_X \frac{\dot{X}}{X} - v_L \frac{\dot{L}}{L} - v_K \frac{\dot{K}}{K},$$

$$v_X = \frac{p_x X}{p_x X + wL + rK} \quad : \text{ Intermediate input cost share}$$

$$v_L = \frac{wL}{p_x X + wL + rK} \quad : \text{ Capital cost share} \tag{8}$$

$$v_K = \frac{rK}{p_x X + wL + rK} \quad : \text{ Capital cost share}$$

Finally, Equation (8) is used in actual growth accounting as the following discrete time approximation:

$$\Delta \ln(TFP) = \Delta \ln(Q) - \bar{v}_X \Delta \ln(X) - \bar{v}_L \Delta \ln(L) - \bar{v}_K \Delta \ln(K) \tag{9}$$

Based on this growth accounting concept, the RIETI JIP Database records annual data including gross production, intermediate inputs, capital stock and capital cost by asset type, and labor input by worker attributes for 108 industries.

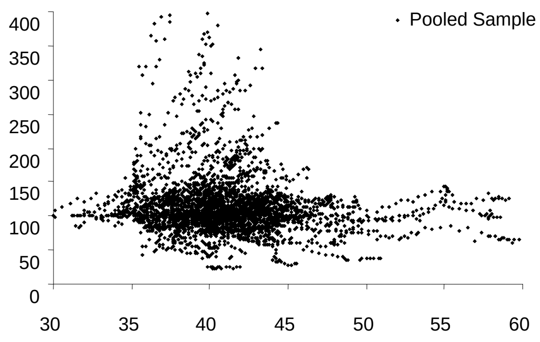
The JIP Database contains labor input indices that consider labor quality and capital input indices that consider capital quality. That is, L and K in Equation (9) are not man hour labor input and actual capital stock, but, respectively, a labor input index, in which differences in productivity due to worker attributes (age, sex, academic achievement, job position) have been taken into consideration, using wage data, and a capital input index, in which differences in productivity for different types of capital have been taken into consideration, using capital cost data. TFP in the JIP Database is determined following Equation (9) by subtracting the contribution of L and K formulated in this way from the rate of growth.

In this way, productivity dependent on the attributes of workers and capital is excluded from TFP in the JIP Database. However, age is one of these worker attributes. Considering the purpose of the present research – to determine the effect of the aging of workers on productivity and the capacity for technological innovation in the macroeconomy, TFP as formulated in the JIP Database could not be used without modification. The studies discussed in this report therefore employed TFP recalculated using Equation (9), with L as man hour labor input (number of workers multiplied by working hours) and K as actual capital stock.

(2) Model for nonlinear panel estimation

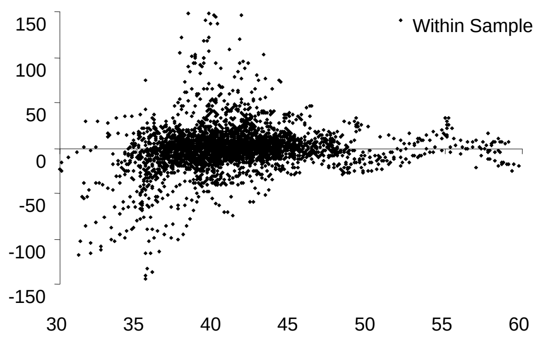
As Figures 3-A1 and 3-A2 in this section show, an inverse U relationship exists between average worker age and TFP, with the peak in the mid-40s. The same relationship holds in the case of real wages (Figures 3-A3 and 3-A4). Figures 3-A1 and 3-A3 plot deviations from the period average (i.e. plot data to which a Within transform has been applied).

Figure 3-A1: Average worker age – TFP scatter diagram– Pooled sample



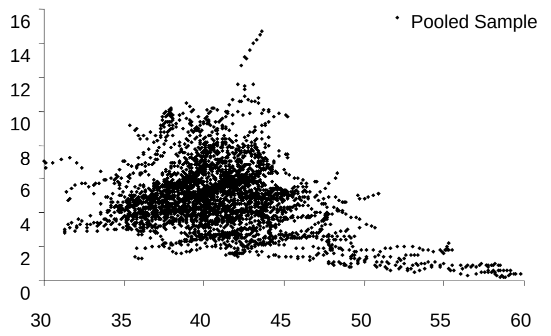
Source: JIP Database, RIETI
Calculations: Credit Suisse

Figure 3-A2. Average worker age – TFP scatter diagram – Within sample



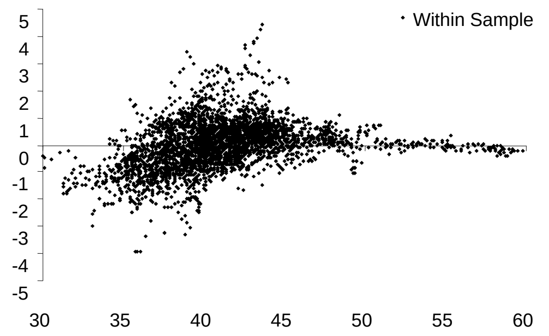
Source: JIP Database, RIETI
Calculations: Credit Suisse

Figure 3-3: Average worker age – Real wages scatter diagram- Pooled sample



Source: JIP Database, RIETI
Calculations: Credit Suisse

Figure 3-4: Average worker age – Real wages scatter diagram -Within sample



Source: JIP Database, RIETI
Calculations: Credit Suisse

Three types of function (inverse Weibull functions, Mincer functions, and third-order polynomial functions were employed in the modeling of the nonlinear relationship between average worker age and TFP and average worker age and real wages. With average worker age as A, the respective model formulas can be expressed as follows:

- Inverse Weibull

$$g(A)=\beta\left[\mu s^{\mu} A^{-\mu-1}\exp\left(-\left(\frac{s}{A}\right)^{\mu}\right)\right]+\alpha \qquad (10)$$

m, s, α, β : Parameters

- Mincer

$$\ln g(A)=\beta A+\gamma A^{2}+\alpha \qquad (11)$$

α, β, γ : Parameters

- Third-order polynomial

$$g(A)=\beta_1 A+\beta_2 A^2+\beta_3 A^3+\alpha \qquad (12)$$

$\alpha, \beta_1, \beta_2, \beta_3$: パラメータ

The inverse Weibull formula above is a generalized linear model with the inverse Weibull function as a link function. Inverse Weibull functions are generated by taking the inverse of the independent variables in Weibull functions, which are chiefly used for the expression of deterioration and lifespan, for example in duration analyses (survival assays). A distribution using an inverse Weibull function as the probability density function is regarded as a type of Pareto distribution.

Mincer’s equation was proposed by Mincer (1974) to consider the effect of the accumulation of human capital on wages, and is widely used in the field of labor economics. This equation offers the advantage of simplicity of interpretation; if the linear term is positive and the quadratic term is negative, the former expresses accumulation and the latter attrition. However, because it is a quadratic equation, it presents the problem of producing an identical gradient for increasing and decreasing tendencies.

The use of fixed effects models and random effects models are standard methods of working with panel data. However, if a nonlinear equation is employed in a random effects model, the analyst has no choice but to rely on a simulation method, and as a result the Hausman test cannot be used to provide a criterion for selection of the model. With this consideration in mind, the present analysis employs fixed effects models exclusively.

Specifically, an additive individual effect of the type shown in Equation (13) was assumed. Following the application of a Within transform in order to eliminate this (Equation (14)), a generalized method of moments (GMM) approach was applied to the nonlinear panel data. The error terms were assumed to follow a normal distribution. Equation (13) is a general equation for TFP and real wages, with no specification of particular functions.

$$Y_{i,t} = g\left(A_{i,t}, \beta\right) + \mu_i + e_{i,t} \tag{13}$$

$Y_{i,t}$: TFP or real wages for industry i at time t

$A_{i,t}$: Average age of workers in industry i at time t

μ_i : Individual effect of industry i

$e_{i,t}$: 誤差項

The application of a Within transform generates the following equation:

$$\hat{Y}_{i,i} = \hat{g}\left(A_{i,t}, \beta\right) + \hat{e}_{i,t} \tag{14}$$

where :

$$\hat{Y}_{i,t} = Y_{i,t} - \sum_t Y_{i,t} \Big/ T$$

$$\hat{g}_{i,t} = g_{i,i} - \sum_t g\left(A_{i,t}, \beta\right) \Big/ T$$

In this manner, the fixed effects model generates the shared shapes when an attempt is made to employ the optimum curve for each industry. Table 3-5 shows the results generated by the fixed effects model for the three equation types.

Table 3-5: Results for TFP curves and real wages curves generated by fixed effects

TFP curve	Fixed effects model	Calculated value	t value	Real wage curve	Fixed effects model	Calculated value	t value
Inverse Weibull equation	mu	4.3	(47.8)	Inverse Weibull equation	mu	4.4	(20.4)
	s	48.1	(167.6)		s	45.9	(63.8)
	beta	3194.0	(81.8)		beta	117.0	(45.9)
	AIC	12,679			AIC	10,686	
	Peak age	45.8			Peak age	43.9	
	Average increase	2.2			Average increase	5.4	
	Average decrease	-0.6			Average decrease	-2.3	
Mincer's equation	beta	0.25	(16.7)	Mincer's equation	beta	0.25	(13.5)
	gamma	-0.003	(-15.9)		gamma	-0.003	(-6.2)
	AIC	14,819			AIC	11,302	
	Peak age	47.3			Peak age	45.4	
	Average increase	1.7			Average increase	1.5	
	Average decrease	-1.9			Average decrease	-2.2	
Third-order polynomial equation	b1	328.7	(16.9)	Third-order polynomial equation	b1	1.8	(11.9)
	b2	-6.88	(-15.7)		b2	-0.03	(-9.0)
	b3	0.048	(14.6)		b3	0.000	(2.6)
	AIC	12,832			AIC	11,263	
	Peak age	43.9			Peak age		
	Average increase	9.0			Average increase	4.0	
	Average decrease	0.8			Average decrease		

Source: JIP Database, RIETI
Calculations: Credit Suisse

Chapter 4 Estimates of Labor Productivity from the Perspective of Age Groups

Masatoshi Jinno

[Abstract]

Labor productivity was estimated for different age groups, and the effect of the future aging of Japan's population on productivity was projected. This research differs from previous research in employing more detailed age groupings and in considering productivity for industry as a whole rather than limiting itself to the manufacturing sector. The results show that labor productivity in relation to age basically describes an inverse U shape, with productivity peaking when workers are in their 40s. When productivity was compared between younger and older age groups, it was found to be higher among the latter. The effect of changes in the age structure of the population on future productivity was considered based on future population estimates. Over the next 10-12 years, Japan's second baby boom generation will enter its 40s, i.e. its period of maximum productivity, and this change in the age structure will produce an effect of increased productivity. However, this effect will not be sufficiently large to continue to compensate for the reduction in the working population due to the decline in the birth rate, and labor power-dependent productivity will therefore decline against its present level in a little over one decade.

1. Estimation of Labor Productivity by Age Group

(Survey of literature concerning labor productivity by age group)

The purpose of this chapter is to conduct estimates of labor productivity by age group using panel data sets for different sectors in Japan. This section will briefly consider the findings of several overseas and Japanese publications concerning the estimation of labor productivity by age group.

Hellerstein, et al. (1999) conducted estimates for three age groups in the manufacturing sector (34 and below, 35-54, and 55 and above), and found that productivity was higher in the 35-54 and 55 and above age groups than the 34 and below age group. Hellerstein and Neumark (2004) also focused on the manufacturing sector, and conducted new estimates using a larger sample size. This study found that while productivity remained high for the 35-54 age group, the productivity of the 55 and above age group was lower than that of the 34 and below age group. Dostie (2006) considered productivity for all industry sectors, and found that the productivity of the 35-54 age group was greater than that of the 55 and above age group, which was in turn greater than that of the 34 and below age group. Collectively, these studies therefore all find that productivity is highest among the 35-54 age group, but leave room for further discussion as to the order of precedence of younger and older age groups.

In Japan, Kawaguchi et al. (2006) focused on the manufacturing industry and used workplace-level data to estimate labor productivity by age group. According to the results of this analysis, worker productivity peaks at around 20 years following the commencement of employment, and the productivity of older workers is higher than that of younger workers. In terms of actual age, it was considered that the productivity of workers reaches its peak in their 40s. However, a comparison of productivity among older and younger segments produced different results for different detailed industry categories such as light industry, heavy industry, and machinery industry. Ochiai (2008) compared productivity for two age categories, 40 and above and below 40, and found that productivity became higher for the higher age group*[1].

The results reported above indicate that while productivity increases with increasing age, it begins to decline above a certain age. Labor productivity by age group therefore displays an inverse U shape. However, opinions are divided as to the relations observed when younger and older segments are compared.

The majority of analyses of the relationship between age groups and labor productivity have focused on the manufacturing industry and have employed workplace-level data. Given that the purpose of the present research was to study the medium-term outlook for Japan, it was essential to conduct the analysis for all industries rather than focusing exclusively on the manufacturing industry. It was also considered that more detailed age groupings would be necessary. This study therefore conducted a macro-level analysis of labor productivity by age group using data for all of Japan’s 106 industry sectors. The analysis employed 11 age groupings. The details of the estimation model are provided in Section 2. Section 3 discusses the details of the data employed, and Section 4 brings together the results of the analysis. The chapter is then summarized in Section 5.

2. Details of Estimation Model

(The productivity of the benchmark age group is considered as 1, and the productivity of other age groups is evaluated against this figure)

This chapter attempts to estimate labor productivity by age group using panel data sets for different industry categories. This section will provide a detailed discussion of the model used for this purpose. Two analyses were conducted using separate age groupings. One employed the three age groups used in previous research (34 and below, 35-54, and 55 and above). The other employed 11 age groups, as follows: 15-19, 20-24, 25-29, 30-34, 35-39, 40-44, 45-49, 50-54, 55-59, 60-64, and 65 and above.

Given the lack of explicit data, the estimation of labor productivity for different age groups is not a simple task. The ratio of workers in each age group was therefore added to the production function separately to the labor input, defining the production function in such a way that the effect of age groups on productivity would be absorbed. I.e., the production function was defined to demonstrate the effect of the specific age ratio on produced value.

$$Y_t^j = Ae^{\phi^j} e^{\phi t} K_t^{j\,\alpha 1} L_t^{j\,\alpha 2} M_t^{j\,\alpha 3} Div_t^j P_t^j \qquad (1)$$

Here, $P_t^j \equiv \exp\left(a_1\left(L(1)_t^j / L_t^j\right)\right) \exp\left(a_2\left(L(2)_t^j / L_t^j\right)\right) \exp\left(a_3\left(L(3)_t^j / L_t^j\right)\right)$, P_t^j expresses the sum of the effect of each age ratio. Each variable is the variable for the jth industry in the tth period. Y_t^j is the value of production, K_t^j is physical capital stock, M_t^j is intermediate input, $L(i)_t^j$ is the number of workers in the ith age group, and L_t^j is the total number of workers in each industry sector. Div_t^j is the standard deviation of the worker age structure, and expresses the degree of scattering in the age structure.

The intuitive implication of Equation (1) can be described as follows. In this chapter, it is hypothesized that the productivity of workers will differ in each age group. It can be considered that the productivity of workers is composed of (A) a segment that differs depending on the age group, and (B) a segment that is homogeneous irrespective of age group, and that production in the production function would be affected through both of these channels. These two channels are expressed in Equation (1). (B), the segment that is homogeneous irrespective of age group, appears as L_t^j, and (A), the segment that differs depending on the age group, appears as $\left(L(1)_t^j / L_t^j\right)$, expressed as the ratio for each age group. The total of the effects of these two factors becomes labor productivity by age group.

Dividing Equation (1) by L_t^j and taking logarithms gives

$$\log\left(y_t^j\right) = \log A + \phi^j + \phi t + \alpha_1 \log\left(k_t^j\right) + \alpha_3 \log\left(m_t^j\right) + \alpha_4 \log\left(Div_t^j\right)$$

$$+ a_1 l(1)_t^j + a_2 l(2)_t^j + a_3 l(3)_t^j$$

Here y_t^j, k_t^j, and m_t^j respectively represent production value, amount of capital, and amount of intermediate input per worker. $l(i)_t^j$ is defined as $l(i)_t^j \equiv L(i)_t^j / L_t^j$, and represents the ratio of the number of workers in the ith age group to the total number of workers. Constant return to scale has been assumed for the amount of capital, the amount of labor, and the amount of intermediate input.

Taking the externality of the 1st age group as 1, the equation was reorganized as follows:

$$\log(y_t^j) = \log A + \phi^j + \phi t + \alpha_1 \log(k_t^j) + \alpha_3 \log(m_t^j) + \alpha_4 \log(Div_t^j) + l(1)_t^j + a_2 l(2)_t^j + a_3 l(3)_t^j \quad (1')$$

Taking a first difference gives

$$\log(y_t^j / y_{t-1}^j) = \phi + \alpha_1 \log(k_t^j / k_{t-1}^j) + \alpha_3 \log(m_t^j / m_{t-1}^j) + \alpha_4 \log(Div_t^j / Div_{t-1}^j) + (l(1)_t^j - l(1)_{t-1}^j) + a_2 (l(2)_t^j - l(2)_{t-1}^j) + a_3 (l(3)_t^j - l(3)_{t-1}^j) \quad (2)$$

In the following section, estimates will be conducted using panel data sets for different industry categories and Equations (1') and (2). In addition, productivity for the worker ratio for each age group will be calculated. The focus of the analysis will be a_i, which expresses productivity by age group.

3. Data

The data employed covered the period 1974-2006. Figures for actual production value, number of workers by age group, actual capital stock, and value of intermediate input were obtained from the JIP 2009 database

(http://www.rieti.go.jp/database/JIP2009/index.html), and figures for the number of working hours by age group were drawn from the Basic Survey on the Wage Structure, published by the Ministry of Health, Labor and Welfare. The descriptive statistical data can be summarized as shown in Figure 4-1.

Figure 4-1 Descriptive statistical data (Period: 1973-2006)

Benchmark: 2000	(1) Total data: 106 industry categories		(2) Industry categories following removal of government-related and agricultural categories: 90 categories		(3) Manufacturing industry-related categories: 52 categories	
(Million yen) (1,000 people × hours) (Person)	Average	Standard deviation	Average	Standard deviation	Average	Standard deviation
Actual physical capital	6,674,036	8,536,937	6,945,189	8,607,499	4,829,039	4,020,984
Value of intermediate input	7,264,914	13,410,683	6,839,714	12,273,533	3,158,643	3,112,755
Value of intermediate input	3,227,131	3,827,012	3,519,570	3,954,001	3,147,602	2,725,256
Total number of workers × Working hours	103,000	166,000	99,054	170,000	47,486	47,847
Number of workers in 15-19 age group	13,809	32,087	14,976	34,403	7,618	11,458
Number of workers in 20-24 age group	56,485	101,127	57,938	107,098	24,983	25,019
Number of workers in 25-29 age group	63,506	104,195	63,728	108,904	28,063	26,054
Number of workers in 30-34 age group	63,056	102,426	63,173	106,918	29,606	29,316
Number of workers in 35-39 age group	65,940	107,076	65,705	111,513	32,421	34,067
Number of workers in 40-44 age group	69,081	112,595	68,107	116,375	34,671	37,009
Number of workers in 45-49 age group	68,637	112,381	66,630	114,495	34,144	36,149
Number of workers in 50-54 age group	63,520	104,551	60,549	104,736	30,978	32,726
Number of workers in 55-59 age group	51,471	88,415	47,618	86,112	23,566	26,192
Number of workers in 60-64 age group	33,499	65,869	28,487	57,184	12,016	15,565
Number of workers in 65 and above age group	37,793	94,445	27,191	63,969	10,551	16,140
Standard deviation in worker age structure	1,232,956	2,076,906	1,031,002	1,633,209	550,274.2	553,761.6
	3604		3060		1768	

4. Results of Estimates

(Worker productivity peaks in the 40s)

First, estimates were conducted for three age groups (34 and below, 35-54, and 55 and above), to enable comparison with previous research. Calculations were conducted using data for 106 sectors (the JIP108 classifications, excepting the Housing sector, for which value-added corresponds to imputed rent, and Activities not Elsewhere Classified), for 90 sectors following the exclusion of agriculture- and government-related sectors (JIP classification numbers: 7-97, excepting 72), and for 52 manufacturing sectors(JIP classification numbers: 8-59). Figure 4-2 shows results for Equation (1). A two-way fixed effects model was employed in the calculations.

Figure 4-2 Two-way fixed effects model

Coefficient	(1) Total data: 106 industry categories	(2) Industry categories following removal of government-related and agricultural categories: 90 categories	(3) Manufacturing industry-related categories: 52 categories
Constant term	1.283*** (6.452)	-1.276*** (-13.798)	-1.749*** (-6.275)
Amount of capital per person	0.090*** (6.471)	0.159*** (13.103)	0.046 (2.226)
Amount of intermediate input per person	0.989*** (66.544)	0.653*** (40454)	1.130*** (53.829)
Standard deviation of structure of working population	-0.158*** (-10.628)	1.88E-08*** (2.783)	0.113*** (5.543)
Ratio of workers in 35-54 age group	2.246*** (22.139)	1.400*** (8.867)	1.714*** (9.982)
Ratio of workers in 55 and above age group	1.919*** (13.216)	1.372*** (10.978)	-0.048 (-0.181)
A.R-squared	0.965	0.966	0.976
D.W.	0.119	0.082	0.201

Notes: ***: 1% significance; **: 5% significance; *: 10% significance. Separate fixed effects and time-based fixed effects were also calculated, but are not shown here.

For each of the three sets of results, the Durbin-Watson values are low, and negative serial correlation may be suspected. Unit root tests were therefore conducted for each type of calculation, with the following results (the superscripts 1, 2, and 3 respectively represent calculations for Total data, Data excepting agriculture- and government-related categories, and Manufacturing-related categories):

$$\Delta e_t^1 = -\underset{(-3.86E-14)}{(4.18E-17)} - \underset{(-12.641)}{0.073 e_{t-1}^1}{}^{***}$$

$$\Delta e_t^2 = \underset{(3.570)}{(0.004)}{}^{***} - \underset{(-15.291)}{0.040 e_{t-1}^1}{}^{***}$$

$$\Delta e_t^3 = -\underset{(-1.44E-14)}{(2.33E-17)} - \underset{(-10.305)}{0.111 e_{t-1}^1}{}^{***}$$

The null hypothesis that a negative serial correlation exists cannot be discarded for any of the calculations. This indicates that the correlation is artificial. The calculations were therefore conducted again using a difference model. The results are shown in Figure 4-3.

As Figure 4-3 shows, the results of calculations for each grouping of industry categories generated largely identical results. With regard to the differences in labor productivity between age groups, because the productivity of the 34 and below age group was defined as 1, a coefficient higher than 1 indicates that the age group in question displays a higher level of labor productivity than the 34 and below age group. Figure 4-3 shows that the 35-54 and 55 and above age groups display coefficients higher than 1. In descending order, the results are: 35-54 age group, 55 and above age group, and 34 and below age group. Significant negative results were also obtained for the standard deviation of the worker age structure, which expresses the status of scattering of the age structure. This indicates that the rate of growth of production value declines in proportion to the degree of scattering of the worker age structure.

Figure 4-3 Difference model

Coefficient	(1) Total data: 106 industry categories	(2) Industry categories following removal of government-related and agricultural categories: 90 categories	(3) Manufacturing industry-related categories: 52 categories
Constant term	0.003** (2.124)	0.002 (1.258)	0.002 (1.556)
Amount of capital per person	0.088*** (4.742)	0.089*** (4.343)	0.072*** (2.595)
Amount of intermediate input per person	0.625*** (28.624)	0.666*** (30.382)	0.756*** (33.178)
Standard deviation of structure of working population	-0.149*** (-6.154)	-0.120*** (-4.832)	-0.065** (-2.214)
Ratio of workers in 35-54 age group	1.819*** (15.143)	1.803*** (14.444)	1.828*** (14.116)
Ratio of workers in 55 and above age group	1.681*** (10.069)	1.701*** (9.312)	1.703*** (9.178)
A.R-squared	0.602	0.635	0.711
D.W.	1.730	1.729	1.890

Notes: ***: 1% significance; **: 5% significance; *: 10% significance. The heterogeneity of variance of the cross-section was corrected and a White corrected covariance matrix was employed. Because the 34 and below age group was defined as representing 1, it does not appear on the table.

A linear difference model using five-year increments was employed in calculations of labor productivity for more detailed age groups. The results are shown in Figure 4-4. Excepting the fact that productivity for the 50-54 age group is considerably lower than productivity for the contiguous age groups on both sides, the results shown in Figure 4-4 indicate that the relationship between worker age and productivity describes an inverse U shape. The coefficient for the ratio of workers in the 65 and above age group was not significant in the calculations using data from which agriculture- and government-related categories had been excepted and calculations using data for manufacturing industry-related categories. This is thought to be because there is no significant difference between the productivity of workers in this age group and that of workers in the 15-24 age group. The labor productivity of the 65 and above age group can therefore be considered approximately equivalent to that of the 15-24 age group.

Figure 4-4 5-year increment difference model

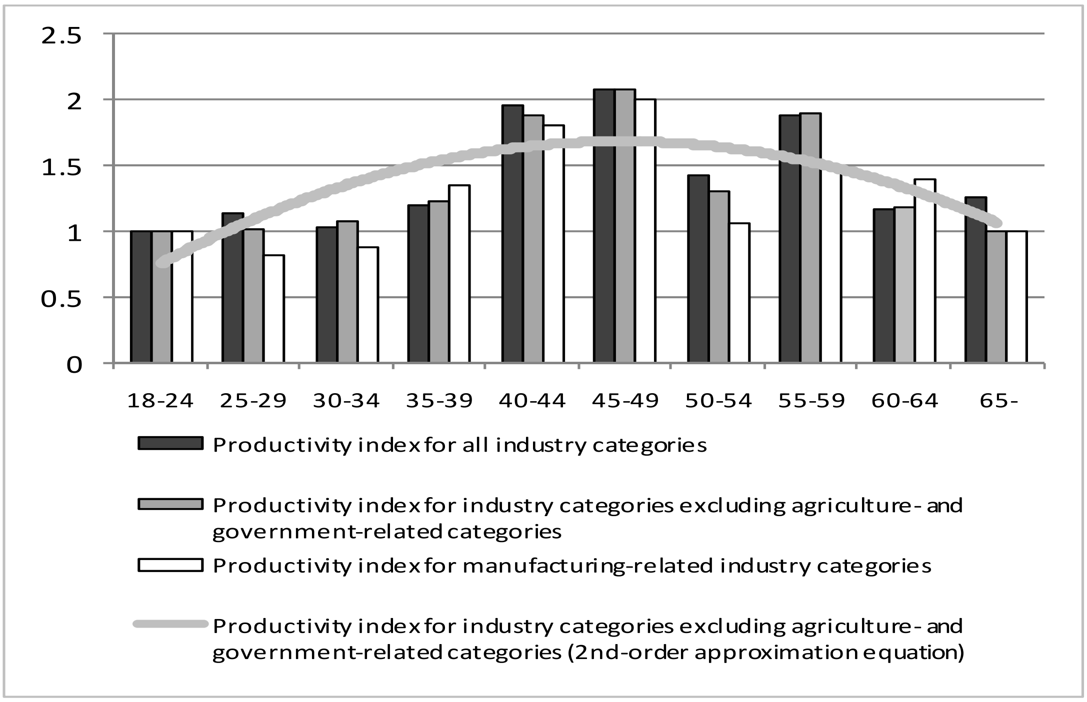
Benchmark: 2000	(1) Total data: 106 industry categories	(2) Industry categories following removal of government-related and agricultural categories: 90 categories	(3) Manufacturing industry-related categories: 52 categories
(Million yen) (Person)	0.005*** (2.942)	0.005** (2.699)	0.006*** (3.527)
Actual physical capital	0.067*** (3.510)	0.066*** (3.071)	0.056* (1.892)
Value of intermediate input	0.619*** (29.107)	0.655*** (29.778)	0.742*** (30.975)
Standard deviation of structure of working population	-0.180*** (-7.504)	-0.156*** (-6.089)	-0.093 (-2.757)
Number of workers in 25-29 age group	1.178*** (6.355)	1.015*** (5.643)	0.778*** (4.403)
Number of workers in 30-34 age group	1.035*** (6.300)	1.089*** (6.587)	0.851*** (4.863)
Number of workers in 35-39 age group	1.259*** (7.375)	1.287*** (7.163)	1.428*** (8.266)
Number of workers in 40-44 age group	2.263*** (12.442)	2.119*** (11.365)	1.962*** (9.271)
Number of workers in 45-49 age group	2.419*** (13.138	2.380*** 12.555	2.206*** (11.399)
Number of workers in 50-54 age group	1.564*** (7.610	1.390*** (6.552)	1.075*** (4.365
Number of workers in 55-59 age group	2.148*** (8.329)	2.137*** (7.946)	1.594*** (6.786)
Number of workers in 60-64 age group	1.228*** (3.628)	1.225*** (3.013)	1.465*** (4.041)
Number of workers in 65 and above age group	1.335*** (4.089)	0.442 (0.837)	0.285 (0.504)
A.R-squared	0.621	0.651	0.721
D.W.	1.753	1.758	1.921

Notes: ***: 1% significance; **: 5% significance; *: 10% significance. The heterogeneity of variance of the cross-section was corrected and a White corrected covariance matrix was employed. Because the 15-24 age group was defined as representing 1, it does not appear on the table.

Figure 4-5 shows results obtained when the labor allocation rate is added to productivity figures, i.e. the marginal productivity of labor, as a bar graph*[2]. For all the calculations, marginal productivity displays a rapid increase in the 40s. It can therefore be considered that in the case of Japan, labor productivity reaches its peak when workers are in their 40s, and remains high in older age groups; it appears that the labor productivity that has been realized does not simply fade away. The result that labor productivity peaks in the 40s is consistent with the result obtained by previous research (Kawaguchi et al.). Long-term calculations and calculations for multiple sector classifications also showed that labor productivity peaks in the 40s.

The fact that companies, based on a concept of long-term employment, have established stable employment environments and conducted extensive in-house training can also be considered to be a factor in the high productivity of workers in their 40s. Leaving aside the argument as to whether a system of long-term employment is desirable, if companies were to discontinue in-house training, it might not be possible to maintain the present high level of productivity among workers in their 40s. This factor must also be taken into consideration.

Figure 4-5 Productivity indices for five-year age groups
(Productivity of 18-24 age group defined as 1)



Note: Labor allocation rate added to productivity figures for each age group, with figures for 18-24 age group defined as 1.

(A period of a little over 10 years is available for policy action)

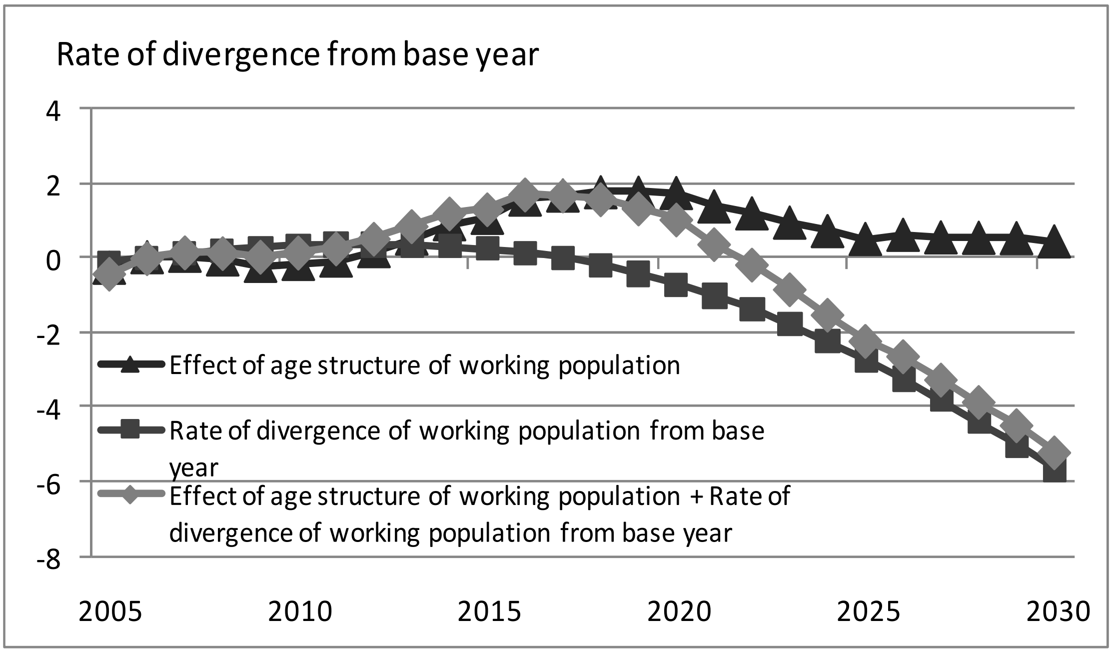
Next, the future effect of the structure of the working population on productivity was calculated using employment rates by age group (1973-2006 averages) based on the Male-Female Population by Age Group: Estimates of Median Births and Deaths published by the National Institute of Population and Social Security Research, and the Labor Force Survey published by the Statistical Survey Department of the Statistics Bureau of the Ministry of Internal Affairs and Communications. The results are shown in Figure 4-6.

The vertical axis of Figure 4-6 shows the rate of divergence of the working population from 2006 figures (2006, the final year of the calculation period, was used as the base year). The results show that due to the declining birth rate, the working population will fall below the figure for the base year around 2017, and will then continue to decline. The effect of the age structure of the working population is comparatively high from 2015 to 2025, when the second baby boom generation enter their 40s, but this effect does not persist for the long-term and is declines following this period. These variables combined can be considered to represent the combined effect of the size of the working population and the age structure of the working population. As the results in Figure 4-6 show, the combined value for these variables remains positive until around 2020.

This indicates that, assuming that the labor productivity of each age group considered remains the same as it is at present, productivity will be maintained until about 2020, when it will fall below present levels. Even if policies to increase the birth rate were to be adopted immediately and were to have a dramatic effect, at least 40 years would be required before the generation born this year reached the peak of its productivity in its 40s. Some 30 years from 2020, labor productivity will have dropped well below present levels. The next ten years is the period for action. Within this ten-year period, it will be essential to give extensive consideration to measures that can be effected for the following thirty years.

Here, I would like to focus once again on the employment rate by age group. Data for changes in the working population were used in Figure 4-6; this data shows the actual status of employment. If the status of employment continues into the future as it has to the present, the results of these calculations can be applied to the future. However, if there is a divergence between past data and present trends, the calculation results will lose meaning. It is therefore necessary to consider the nature of present trends.

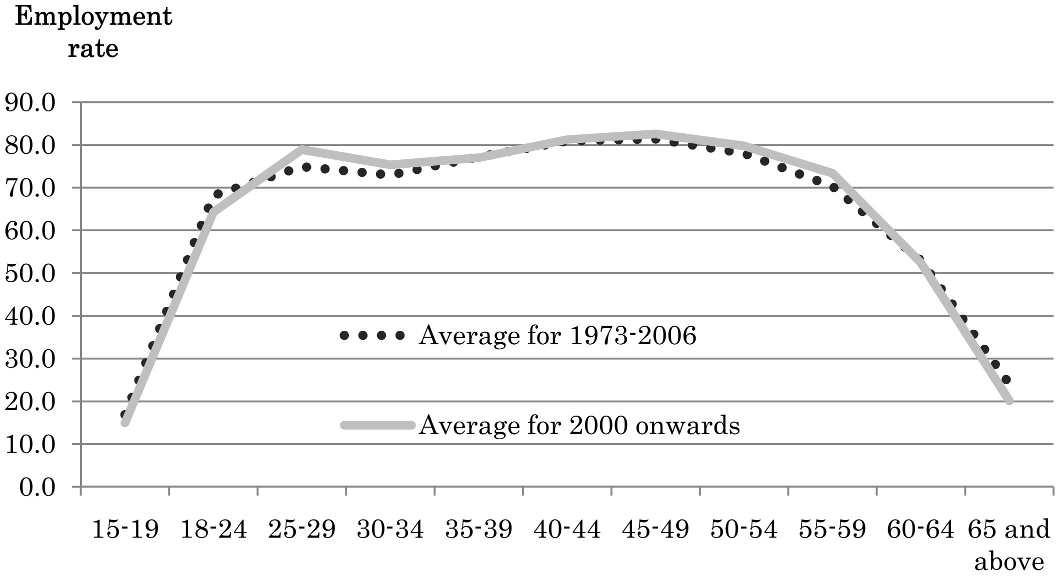
Figure 4-6 Estimates of future effect of age structure of working population and changes in the working population



Note: Formulated using data from Male-Female Population by Age Group: Estimates of Median Births and Deaths published by the National Institute of Population and Social Security Research, and the Labor Force Survey published by the Statistics Bureau of the Ministry of Internal Affairs and Communications

Based on the Labor Force Survey published by the Statistics Bureau of the Ministry of Internal Affairs and Communications, averages were taken of the employment rates for each age group for 1973-2006, the period used in the calculations, and of the employment rates from 2000 onwards. The results are shown in Figure 4-7. As Figure 4-7 shows, despite slight divergences for younger and older age groups, there is no dramatic change between data for the past 30 years and the most recent data from 2000 onwards. However, the story becomes rather different when the issue of regular and irregular employment among younger age groups, which has recently attracted considerable attention, is focused on.

Figure 4-7 Employment rate by age group

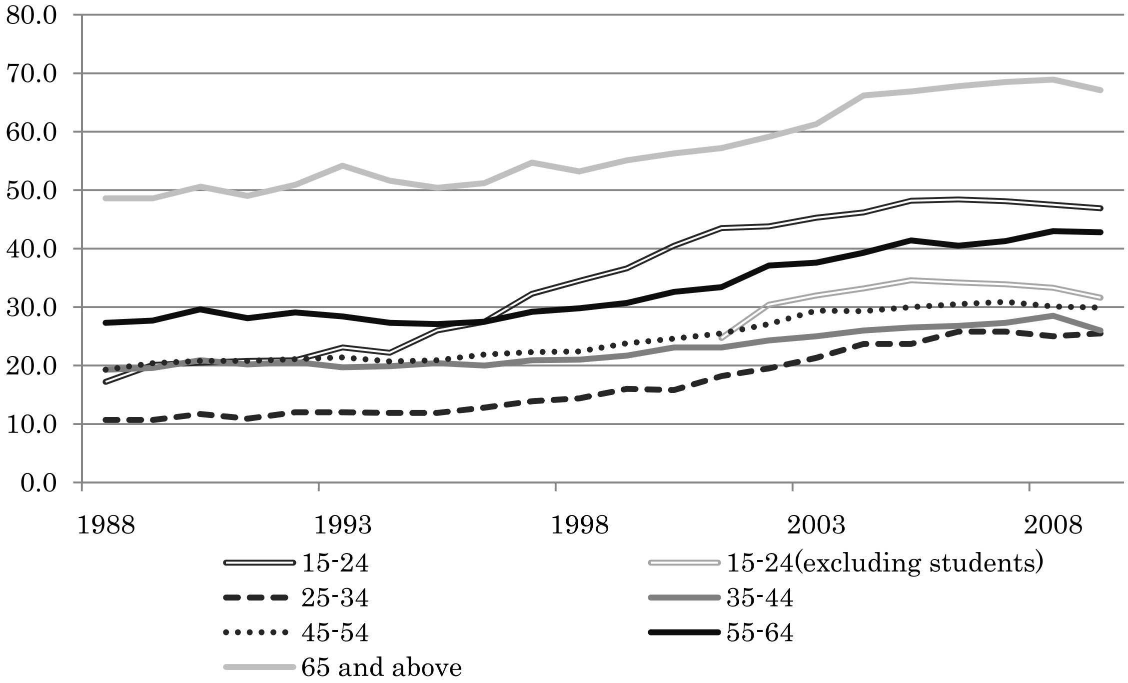


Note: Formulated using data from the Labor Force Survey published by the Statistics Bureau of the Ministry of Internal Affairs and Communications

Figure 4-8 shows the rates of regular and irregular employment for the different age groups. Despite a slight increasing tendency, Figure 4-8 shows the rate of irregular employment among the 35-44 and 45-54 age groups to be comparatively stable. However, a conspicuous increasing tendency from 2000 can be observed for younger age groups, in particular the 25-34 age group. What is the meaning of this tendency? Analyzing Figures 4-7 and 4-8 in tandem, it can be suggested that while the level of employment has been maintained among younger age groups, the form of that employment has shifted towards irregular employment. This can only indicate that employment is becoming unstable among younger age groups.

Figure 4-6 indicated that if forms of employment are maintained enabling companies to continue in-house training as has been the case up to the present, a period of ten years is available for policy action to address the future labor force. However, Figures 4-7 and 4-8 indicate that at present younger people are increasingly entering unstable forms of employment. These unstable forms of employment will prevent them from receiving sufficient in-house training. The calculation results discussed here indicate that there is a rapid increase in productivity when workers reach their 40s, but unstable employment will impede this effect. This point must be given further consideration.

Figure 4-8 Rate of regular and irregular employment



Note: Formulated using data from the Labor Force Survey published by the Ministry of Internal Affairs and Communications

I would now like to briefly consider future policy based on the above analysis. In the current situation of a declining birth rate and a worsening status of employment among younger segments of the population, it will naturally be necessary to adopt enhanced policies to increase the birth rate, and in order to at least maintain labor productivity at its present level, it will also be essential to enhance policies to promote increased full-time employment of young people by companies and to create stable employment environments enabling sufficient in-house training. In addition, in order to mitigate the approaching effect of the decline in the population during the next ten years, the period during which productivity can be expected to continue to increase, we should build a bulwark by actively employing elderly citizens, whose labor productivity remains at a comparatively high level. I would like to conclude by stressing this point.

5. Conclusion

In this chapter, I have estimated labor productivity by age group using long-term panel data for Japan. These estimates have shown that the labor productivity of Japanese workers peaks when those workers are in their 40s. In addition, the results show that labor productivity among older age groups remains higher than that of younger age groups, suggesting that the labor productivity that has been developed does not simply wane as workers get older. Future population projections show that the ratio of workers in their 40s in the general working population will decline below present levels around 2020. It will be essential during the next decade to actively adopt policies that will serve to boost labor productivity. As part of this policy initiative, we can consider policies to boost the birth rate, the enhancement of education and training by companies, and, during the next decade, the creation of an environment that encourages the active employment of elderly citizens.

The analysis discussed in this chapter was conducted on the basis of comparatively limited data sets. In future, it will be necessary to conduct the analysis using more detailed categories, for example by educational level, gender, etc. Despite the fact that many such points must be borne in mind in relation to this analysis, I believe that there remains considerable significance in conducting an analysis of the effect of the structure of the working population in the near future.

[Notes]

*1 For a survey of the literature concerning the gap between productivity and wages, see Chapter 2 of this report.

*2 The benchmark figure of 1 for the 15-24 age group is used for the 65 and above age group in for industry categories excluding agriculture- and government-related categories and for the manufacturing-related categories, for which significant results were not obtained. For the manufacturing-related categories, results for the 25-29 and 30-34 age groups are markedly lower than the benchmark figure for the 15-24 age group. These estimates do not take educational level or gender into consideration, and simply reflect differences for age groups. (This can also be said of the other estimates). Because of this, the effect of factors other than age may be expressed in the results without being explicit.

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Chapter 5 Aging of the Population and Employment among the Young: A Reconsideration of the Relationship

Souichi Ohta

[Abstract]

It has been suggested that employment opportunities are being lost to the young because companies are retaining their existing middle-aged or elderly employees. In considering employment issues among the young, the analysis conducted here did not confine its focus to the accession rate for young people, but also studied the net accession rate (accession rate − separation rate) and the employment growth rate ((Number of young employees this year − Number of young employees in previous year) / Number of young employees in previous year), which show the actual rate of increase in employment among the young. An analysis of the net employment rate indicated the possibility that companies are adjusting their employee intake, seeking an optimum employee age structure. In addition, an analysis of industrial panel data showed that the rate of employment of younger people tends to increase the more the age structure of a company is weighted towards middle-aged or elderly employees, and that companies with high ratios of middle-aged and elderly employees are actually reducing new employment of workers in these age groups. This suggests that Japanese companies have adopted a strategy of reducing (or controlling the increase of) employee categories of which they have an excess, and of increasing (or controlling the reduction of) employee categories of which they have a shortage, seeking to maximize the benefits available from an optimal employee age structure.

1. Introduction

In the world of economics textbooks, which is to say, a world of perfect competition, long-term unemployment does not exist. This is because unemployment indicates an over-supply in the labor market, and this would function as a pressure driving down the wages of existing workers. If wages decline smoothly, demand for labor will increase among companies, and the unemployed will ultimately find employment. In the world of the real economy, information is not completely available as it is in the world of textbooks, and in many cases wages are rigid. This tends to lead to a situation in which jobs are “allocated” among job seekers, i.e., some job seekers will find employment, and some will not.

Naturally, there is a diverse range of “jobs,” and some are more prone to this phenomenon of “allocation” than others. Comparatively simple jobs, and jobs for which the wage level is generally agreed upon, are not prone to “allocation.” If an over-supply of labor for jobs of this type occurs, wages will be adjusted downwards. On the other hand, the link between wage levels and the market is weak in the case of jobs which demand employees to increase their skills in the company (and jobs for which high wages are generally agreed upon). In addition, “job competition,” in which the superior candidate receives the job, is more important than “wage competition,” in which the first candidates selected are those prepared to accept the lowest wages. This point is expressed succinctly in Thurow’s “job competition model,” but also accords with the intuitive feeling of most people.

When “job allocation” is practiced extensively in the actual labor market, competition arises over jobs. When someone fills a job “space,” employment opportunities for other candidates decline by the same amount. Taking competition between educational levels as an example, the majority of white collar positions at large companies are occupied by workers with higher levels of education, and workers with lower levels of education are barred from these jobs. In this sense, in the case of white collar positions at large companies, employment opportunities for workers with lower levels of education have been replaced by employment opportunities for workers with higher levels of education.

Extending this reasoning to age groups, we see that when “good jobs” are occupied by middle-aged and older employees, it will be difficult for young, recently graduated job seekers to find such positions. Because maintaining employment among full-time employees is viewed as particularly important by Japanese companies, they display a strong tendency to vigorously resist letting workers go even in a recession. Because of this, the process of employee adjustment focuses most strongly on hiring choices, and it is the younger age segments, centering on recent graduates, who are most affected by this phenomenon.

Genda (2004) termed this displacement of employment opportunities for young people by middle-aged and older workers the “replacement effect theory,” and conducted a detailed empirical analysis. This research, which showed using workplace-level data that the higher the rate of employment of middle-aged or older workers in a workplace, the more employment opportunities are lost by younger people, is still having considerable impact even today.

This paper will reconsider the “replacement effect theory” from a different perspective to that adopted by Genda (2004). It will analyze the relationship between employment opportunities for the young and the ratio of middle-aged and older individuals in the population using a variety of published data.

2. Analytic Perspective

It is well known that restricting new employment is the standard procedure employed by Japanese companies to adjust employment in a recession, and that this method is prioritized over letting employees go in order to restructure. If new employment is restricted, the level of employment can be reduced, given that it is possible to expect natural attrition of employee numbers as a result of retirement or cessation of employment for other reasons. Because young people, and particularly recent graduates, make up the bulk of candidates for new employment, employment of young people declines conspicuously during a recession.

Company actions of this type can also be demonstrated statistically. For example, using data classified by industry and time period from the Survey of Employment Trends conducted by the Ministry of Health, Labour and Welfare, Ota (2009) examined the relationship between the increase or decline in employment for all age groups and the increase or decline in employment by age group. The results showed that while a 1% decline in total employee numbers translated into a 1.5% decline in employment among the 15-19 age group and a 1.1% decline in employment among the 20-24 age group, it represented a decline of only around 0.8% in employment among the 40-44 age group.

Similar estimates for employment growth (accession minus separation) showed that when the number of employees declines by one person for all age groups, employment declines by 0.16 persons among the 15-19 age group and 0.18 persons among the 20-24 age group, while it declines by only 0.06 persons among the 40-44 age group.

A variety of factors generating such a situation can be conjectured, and one of these is that Japanese companies tend to protect their existing full-time workers by restricting employment of young people. However, the "replacement effect theory" discussed above is not limited to this phenomenon. Going further, the aging of the age structure of full-time employees will also function to restrict employment of young people. If the "replacement effect theory" is correct, then a future reduction in employment opportunities for young people is looming in Japan, where the working population is aging. In fact, Genda (2004) found that employment of recent and future graduates is more strongly limited in workplaces with a higher ratio of workers aged 45 and above. However, there are still points that require consideration with regard to the level to which the aging of the working population will reduce employment among the young.

First, there is the problem of the indices used in the analysis. Analyses up to the present have focused on indices such as the planned rate of hiring of new graduates and the actual rate of employment of young people at each workplace considered. These are clearly important indices, but we must be aware that each is only a single indicator. It is necessary for the rate of new hirings to exceed that of job terminations in a specific year in order for a company to increase its rate of employment of young people in that year. No matter how many young people the company employs, if it lets go more workers than it employs, young people will have lost actual employment. We can therefore argue that the rate of growth in employment is a more important indicator than the rate of employment of young people.

By giving consideration to the relationship between the rate of growth in employment among young people and the age structure of the population, we can also direct our attention to the problem of the optimum age structure for companies. Assuming that companies make the achievement of an optimum worker age structure a target, companies with an excess of middle-aged and older employees should employ young people (or reduce the number of middle-aged and older staff members), and companies with large numbers of younger employees should supplement middle-aged and older workers from outside. In this case, the effect of the age structure on growth in employment would be the exact opposite of that assumed by the "replacement effect theory."

Second, there is another point concerning the relationship between indicators of employment of young people at the company or workplace level and the age structure that merits further consideration. If the average age of company employees increases, there will be a relative decline in the number of young people within the companies. As a result, there will also be an overall decline in the number of young people being terminated from or leaving their positions. If companies hire in order to replace workers that have been terminated or have left their positions, then there will be a decline in the hiring of young people corresponding to the decline in young people being terminated from or leaving their positions. If this is the case, then part of the effect of the average age structure reflects the age structure of employees who have been terminated from or have left their positions.

Third, even if "aged" companies are restricting their employment of young people, we cannot assume that the logic behind this is empirically clear. If there are fixed production factors that can substitute for the labor of young people, and if those production factors increase, there may be a negative impact on employment of young people. However, here we face the problem that this effect of substitution is not limited to middle-aged and older workers aged 45 and above, but also to workers in their 30s. The reason that analyses have thus far focused on middle-aged and older workers is that in Japan, given the combination of a difficulty in letting employees go and an age-based wage system, the high cost of wages for middle-aged and older workers can be considered to have an effect on the desire to employ young people. If the cost of wages for middle-aged and older workers is an important determining factor, then the ratio of the age groups with the highest wage levels in the company and the percentage of the total wages paid by the company allocated to middle-aged and older workers should affect the employment of young people. It will be necessary to study this point empirically.

The rest of this paper will reexamine the relationship of substitution between middle-aged and older workers and young workers with consideration of these points. While it would be desirable to employ long-term data concerning the full-time employee age structure and wage levels for individual companies, such data is difficult to obtain. This analysis therefore employs published industry-level data.

3. Empirical Analyses

(1) Analysis using Survey of Employment Trends

First, an analysis will be conducted using data from the Survey of Employment Trends published by the Ministry of Health, Labour and Welfare. This survey contains extensive data concerning workers entering and leaving employment, and can be considered to provide suitable data for the analysis of the problems considered here. This analysis uses the number of people entering employment, the number of people leaving employment, and the number of employees, classified by industry and age group. The data covers the period from 1994 to 2003. Data from 2004 onwards will not be employed because revision of the Japanese standard industry classifications has made it difficult to ensure data continuity. In addition, because the focus has been limited to industries for which it was possible to use continuous data, the number of industries represented is lower than the number in the normal industrial classifications. As a result, the sample analyzed is 31 industries × ten years.

The first problem to be considered is the effect of the age structure of an industry on the accession rate of young people in that industry. Here, the accession rate of young people will be defined as the number of individuals aged 15-29 hired, divided by the total number of workers. This provides an indicator of the level of activity of employment of young people in relation to the total number of employees in the industry, and is the explained variable. The main explanatory variable was the industry age structure. Four categories were considered: 1) The percentage of workers aged 30 and above in the total number of workers; 2) The percentage of workers aged 45 and above in the total number of workers; 3) The percentage of workers aged 55 and above in the total number of workers; and 4) The average age*[1]. In addition, industry and year dummies were employed. The analysis was conducted using the least squares method, weighted by the number of workers in each industry category.

Table 1 shows the results of the analysis. Columns (1) to (4) show results obtained by introducing, as the explanatory variable, the age structure at the same point in time as the explained variable. The explained variable, the accession rate for young people, was found by totaling the number of accessions from January to December, and dividing this figure by the total number of workers on the final day of June; here, the age structure at the same point in time, the final day of June, is used as the explanatory variable. A significant negative result at the 1% level was obtained for the ratio of workers aged 30 and above, and significant negative results were also obtained for the ratio of workers aged 45 and above and for the average age. This result therefore indicates that the accession rate among young people is low for companies with older age structures, and thus accords with the "replacement effect theory." However, while a negative result was obtained for the ratio of workers aged 55 and above, the result was not significant.

The most interesting outcome here is the fact that the result for the ratio of workers aged 30 and above is more statistically significant than the result for the ratio of workers aged 45 and above. One interpretation is that a reverse cause and effect relationship is at work, i.e. that the magnitude of the influx of young workers alters the age structures of the companies. In order to deal with this problem, the calculations were conducted again using the age structure for June of the previous year. The results are shown in Columns (5) to (8) in Figure 5-1. Overall, the absolute values of the coefficients are low in comparison to (1) to (4). Significant results were obtained only for the ratio of workers aged 30 and above and for the average age. In this case also, the significance of the results for the ratio of workers aged 45 and above was lower than that of the results for the ratio of workers aged 30 and above. This analysis therefore does not provide conclusive evidence that young people are being sacrificed in order to maintain employment among middle-aged and older workers.

What other factors can then be considered in relation to the results for the ratio of workers aged 30 and above and the average age? In industries that employ large numbers of young people, the number of young people leaving employment also increases correspondingly. If the number of young people leaving employment is frequently supplemented by the hiring of young people, then it is unsurprising that the rate of accession of young people would be high in industries with a high ratio of young people. In order to test this hypothesis, the ratio of workers aged 15-29 leaving employment in the previous year (the percentage of the total number of workers represented by the separation rate for workers aged 15-29) was added as an explanatory variable in addition to the age structure in the previous year. The results are shown in Columns (9) to (12). In all cases, results for the ratio of workers aged 15-29 leaving employment were positive, and the results were within a 5% level of statistical significance, excepting the results obtained when the ratio of workers aged 30 and above was used as the explanatory age structure variable. The introduction of the new variable also reduced the coefficient for the ratio of workers aged 30 and above by approximately two-thirds, and made the coefficient for the average age statistically insignificant. A low rate of hiring of young people to supplement numbers due to a low rate of young people leaving employment can therefore be considered as one reason for the fact that the rate of hiring of young people is low in industries with older age structures.

Table 5-1 Results for rate of accession of young people
(Based on Survey of Employment Trends)

	(1)		(2)		(3)		(4)	
Ratio of workers aged 30 and above	-0.304	***						
(same point in time)	(0.056)							
Ratio of workers aged 45 and above			-0.165	***				
(same point in time)			(0.058)					
Ratio of workers aged 55 and above					-0.071			
(same point in time)					(0.102)			
Average age (same point in time)							-0.010	***
							(0.002)	
Coefficient of determination	0.922		0.888		0.882		0.909	
F	75.82		58.76		62.07		57.19	
Sample size	310		310		310		310	
	(5)		(6)		(7)		(8)	
Ratio of workers aged 30 and above	-0.189	***						
(previous year)	(0.055)							
Ratio of workers aged 45 and above			-0.075					
(previous year)			(0.076)					
Ratio of workers aged 55 and above					-0.046			
(previous year)					(0.087)			
Average age(previous year)							-0.005	**
							(0.002)	
Coefficient of determination	0.895		0.883		0.882		0.887	
F	69.52		63.44		62.99		69.01	
Sample size	310		310		310		310	
	(9)		(10)		(11)		(12)	
Ratio of workers aged 30 and above	-0.127	*						
(previous year)	(0.065)							
Ratio of workers aged 45 and above			-0.009					
(previous year)			(0.074)					
Ratio of workers aged 55 and above					0.019			
(previous year)					(0.077)			
Average age (previous year)							-0.001	
							(0.002)	
Ratio of young people leaving	0.226		0.370	***	0.379	***	0.337	**
employment (previous year)	(0.144)		(0.134)		(0.129)		(0.143)	
Coefficient of determination	0.898		0.894		0.894		0.895	
F	69.98		64.99		63.94		67.24	
Sample size	310		310		310		310	

(Notes) Industry and year dummies were added to the explanatory variables. The least squares method was used, weighted for the number of workers by industry category. Heteroskedasticity-robust standard error was employed. Figures in parentheses represent standard error. ***,**, and * represent 1%, 5%, and 10% levels of significance respectively.

To conclude this section, I will use the rate of growth of employment of young people (defined as the product of subtracting the rate of separation of young people from the rate of accession of young people) as an indicator of growth in the employment of young people, and will conduct an analysis using this as the explained variable. As indicated in the previous section, employment opportunities for young people become more stable as young people become more entrenched, and the net rate of influx of young people into employment should therefore also be an important factor. The analysis used the age structure for the previous year. The results are shown in Table 5-2. The interesting point here is that the coefficients for the age structure are all positive, and are also statistically significant, at a level of 10% for the ratio of workers aged 30 and above. A high ratio of workers aged 30 and above means low numbers of young employees. This may be taken as indicating that young people are actively being hired in industries that have low ratios of young workers. Ota (2009), similarly using data classified by industry, determined a positive correlation between the age structure of people acceding to employment and that of people separating from employment. The results obtained here are consistent with the hypothesis that companies are adjusting their employees, seeking an optimum age structure.

Figure 5-2 Results for net rate of influx of young people to employment (based on Survey of Employment Trends)

	(1)		(2)	(3)	(4)
Ratio of workers aged 30 and above	0.211	*			
(previous year)	(0.123)				
Ratio of workers aged 45 and above			0.130		
(previous year)			(0.144)		
Ratio of workers aged 55 and above				0.125	
(previous year)				(0.176)	
Average age (previous year)					0.007
					(0.005)
Coefficient of determination	0.361		0.348	0.346	0.355
F	4.3		4.5	4.53	4.28
Sample size	310		310	310	310

(Notes) Industry and year dummies were added to the explanatory variables. The least squares method was used, weighted for the number of workers by industry category. Heteroskedasticity-robust standard error was employed. Figures in parentheses represent standard error. ***,**, and * represent 1%, 5%, and 10% levels of significance respectively.

(2) Analysis using Data from Basic Survey on Wage Structure

The robustness of results obtained using one data set cannot be guaranteed. In addition, the Survey of Employment Trends includes data for part-time workers, and it would be desirable to exclude these workers and conduct an analysis exclusively from the perspective of normal full-time employees. Further, the relationship between employment opportunities for young people and the wage structure is another important point of consideration, and it is also therefore desirable to use statistics that include wages by age group. The data that best answer these requirements are found in the Basic Survey on Wage Structure published by the Ministry of Health, Labour and

Welfare. These data will be used in the analysis conducted in this section.

Here also, the data set represents data for industry categories pooled over a time series. The data covers normal full-time workers in the public and private sectors from 1991 to 2003. 57 industry categories were employed, and the period of 13 years therefore gives a sample size of 741. First, the rate of growth in employment was used as the explained variable. This was defined as the number of young employees in the focus year minus the number of young employees in the previous year, divided by the number of young employees in the previous year. First, as in the previous section, we will consider results obtained using the age structure and industry and year dummies as the explanatory variables.

The results are shown in Columns (1) to (4) in Table 5-3. The results were all positive, with levels of statistical significance of 1% for the ratio of workers aged 30 and above, the ratio of workers aged 45 and above, and the average age, and of 10% for the ratio of workers aged 55 and above. Here also, the results show that the rate of growth in employment of young people increases with the aging of the age structure. These results accord with the results obtained in the previous section for the net influx of young people to employment using data from the Survey on Employment Trends.

Here, I would like to investigate the effect of the wage structure. The maintenance of the employment of middle-aged and older employees in companies with seniority-based wage curves occasions significant personnel costs. It is therefore possible, other conditions being the same, that employment opportunities for young people will decline in proportion to the extent to which the wage curve of a company (or industry) is seniority-based. I would therefore like to introduce the ratio between wages in the 45-50 age group and wages in the 20-24 age group, considered as an index of the wage gradient, as an explanatory variable. The wage will be defined here as the monthly fixed cash wage plus one-twelfth of the annual bonus and other special payments. The percentage of total wages paid represented by wage payments to workers aged 45 and above was also calculated and introduced as a variable representing the wage ratio of middle-aged and older workers. The results are shown in Columns (6) to (10) in Figure 5-3.

Figure 5-3 Results for rate of growth in employment of younger workers (Based on data from Basic Survey on Wage Structure)

	(1)	(2)	(3)	(4)
Ratio of workers aged 30 and above (previous year)	0.785 *** (0.175)			
Ratio of workers aged 45 and above (previous year)		1.119 *** (0.264)		
Ratio of workers aged 55 and above (previous year)			0.728 * (0.389)	
Average age (previous year)				0.036 *** (0.008)
Coefficient of determination	0.317	0.318	0.292	0.324
F	3.69	3.6	3.35	3.65
Sample size	741	741	741	741

	(5)	(6)	(7)	(8)	(9)	(10)
Ratio of workers aged 30 and above (previous year)	0.787 *** (0.173)					
Ratio of workers aged 45 and above (previous year)		1.117 *** (0.260)				1.192 *** (0.343)
Ratio of workers aged 55 and above (previous year)			0.724 * (0.389)			
Average age (previous year)				0.036 *** (0.008)		
Wage gradient (Wages of 20-24 age group against wages of 45-50 age group) (previous year)	-0.001 (0.009)	0.001 (0.009)	0.004 (0.009)	-0.002 (0.009)		
Percentage of total wages paid to workers aged 45 and above (previous year)					0.570 *** (0.215)	-0.073 (0.257)
Coefficient of determination	0.317	0.318	0.293	0.324	0.300	0.318
F	3.76	3.76	3.62	3.74	3.61	3.69
Sample size	741	741	741	741	741	741

(Notes) Industry and year dummies were added to the explanatory variables. The least squares method was used, weighted for the number of workers by industry category. Heteroskedasticity-robust standard error was employed. Figures in parentheses represent standard error. ***,**, and * represent 1%, 5%, and 10% levels of significance respectively.

Irrespective of the index of the age structure employed, results for the degree to which wages are seniority-based (i.e., the wage gradient) are all statistically insignificant. In addition, when the wage ratio of middle-aged and older workers was introduced in isolation, the result was positive, but when it was introduced in tandem with a variable for the ratio of workers aged 45 and above, the result was negative and lacking in statistical significance. These results therefore provide no evidence to suggest that a seniority-based wage schedule has a negative impact on employment of younger workers.

(3) Analysis using Data from the JIP Database

At this point, I wish to examine the relationship between the employment growth rate and the age structure using data from the JIP database 2009, compiled by the Research Institute of Economy, Trade and Industry (RIETI). The JIP database contains a variety of annual data necessary for the calculation of sectoral TFP from 1970 to 2006, including labor service input indices and labor input costs that consider capital service input indices and capital cost quality, nominal and real values of gross output and intermediate input, and growth accounting results for the rate of increase in TFP.

The use of this database offers two advantages. First, the industry classifications are comparatively detailed, and the researcher can therefore expect an increase in the number of data. Even if public sector categories and mixed public-private sector categories are excluded, it is still possible to employ data for 89 sectoral categories. Data concerning the number of employees is based on the Population Census conducted by the Statistics Bureau of the Ministry of Internal Affairs and Communications. For years in which no Population Census is conducted, estimates are made based on the Ministry’s Labor Force Survey and other data. The second advantage of using the database is that the use of data for sectoral capital stocks, the number of workers by job type, the number of male and female workers, the number of part-time workers, etc. makes it possible to control a large number of factors and thus estimate the effect of the wage structure more accurately.

The rate of growth of employment of younger workers was again set as the explained variable. The age structure was also employed as the explanatory variable, as previously. In addition, the employee structure by job type for the previous year (five job types), the ratio of female employees for the previous year, the ratio of part-time workers in the previous year (because the data in both these latter cases was available only for every fifth year, linear interpolation was applied), the rate of growth of capital stocks, and industry and time dummies were introduced as explanatory variables. No changes were made in the method of calculation.

The data covered the 16-year period from 1991 to 2006, and the sample size was 1,424.

The calculation results are shown in Figure 5-4. Columns (1) to (4) show results when only the age structure variables are introduced in addition to the industry and time dummies. Results for the ratio of workers aged 30 and above and the average age are positive and significant at a 1% level, while results for the ratio of workers aged 45 and above and the ratio of workers aged 55 and above are positive but not significant. Columns (5) to (8) show the results obtained when the employee structure by job type for the previous year (five job types), the ratio of female employees for the previous year, and the ratio of part-time workers for the previous year were introduced. The introduction of these variables increased the magnitude of the coefficients for the ratio of workers aged 30 and above and the average age. In addition, the coefficients for the ratio of part-time workers in the previous year was statistically significant and positive throughout, indicating that employment of younger workers increases in sectors in which there are numerous part-time workers. The results obtained when the rate of growth in capital stocks was introduced are shown in Columns (9) to (12). The results show a strong positive correlation between growth in capital stocks and the rate of growth of employment of younger workers.

The results show that employment of younger workers is increasing in industries in which there are low numbers of younger employees.

Figure 5-4 Results for the rate of growth of employment of younger workers (Using data from the JIP database)

	(1)		(2)		(3)		(4)	
Ratio of workers aged 30 and above (previous year)	0.259	***						
	(0.071)							
Ratio of workers aged 45 and above (previous year)			0.020					
			(0.092)					
Ratio of workers aged 55 and above (previous year)					0.006			
					(0.096)			
Average age (previous year)							0.008	***
							(0.003)	
Coefficient of determination	0.628		0.618		0.618		0.623	
F	14.16		14.09		14.35		14.36	
Sample size	1424		1424		1424		1424	
	(5)		(6)		(7)		(8)	
Ratio of workers aged 30 and above (previous year)	0.561	***						
	(0.084)							
Ratio of workers aged 45 and above (previous year)			0.099					
			(0.100)					
Ratio of workers aged 55 and above (previous year)					0.026			
					(0.097)			
Average age (previous year)							0.016	***
							(0.003)	
Job type ratio (Specialized/ technical; previous year)	0.101		0.034		0.022		0.079	
	(0.174)		(0.190)		(0.189)		(0.185)	
Job type ratio (Managerial; previous year)	1.311	***	0.505		0.407		1.010	***
	(0.313)		(0.314)		(0.289)		(0.317)	
Job type ratio (Clerical; previous year)	0.155		-0.199		-0.198		-0.061	
	(0.206)		(0.236)		(0.239)		(0.216)	
Job type ratio (Sales; previous year)	-0.162		-0.122		-0.124		-0.154	
	(0.167)		(0.172)		(0.174)		(0.172)	
Job type ratio (Service; previous year)	0.411	**	0.094		0.084		0.194	
	(0.161)		(0.174)		(0.180)		(0.160)	
Ratio of female employees (previous ye	0.003	**	0.000		0.000		0.001	
	(0.001)		(0.001)		(0.001)		(0.001)	
Ratio of part-time employees (previous	0.002	***	0.002	**	0.002	**	0.002	***
	(0.001)		(0.001)		(0.001)		(0.001)	
Coefficient of determination	0.656		0.628		0.628		0.642	
F	16.3		14.4		14.53		15.48	
Sample size	1424		1424		1424		1424	

Figure 5-4 (Continued)

	(9)		(10)		(11)		(12)	
Ratio of workers aged 30 and above	0.540	***						
(previous year)	(0.091)							
Ratio of workers aged 45 and above			0.137					
(previous year)			(0.089)					
Ratio of workers aged 55 and above					0.094			
(previous year)					(0.094)			
Average age (previous year)							0.017	***
							(0.003)	
Rate of growth of capital stock	0.320	***	0.339	***	0.341	***	0.346	***
	(0.059)		(0.070)		(0.072)		(0.065)	
Job type ratio (Specialized/ technical;	-0.021		-0.087		-0.102		-0.046	
previous year)	(0.167)		(0.183)		(0.182)		(0.177)	
Job type ratio (Managerial; previous	1.009	***	0.256		0.120		0.747	**
year)	(0.350)		(0.336)		(0.316)		(0.345)	
Job type ratio (Clerical; previous year)	0.169		-0.172		-0.172		-0.027	
	(0.201)		(0.241)		(0.247)		(0.217)	
Job type ratio (Sales; previous year)	-0.106		-0.064		-0.071		-0.097	
	(0.157)		(0.162)		(0.165)		(0.162)	
Job type ratio (Service; previous year)	0.337	**	0.030		0.002		0.132	
	(0.157)		(0.168)		(0.173)		(0.154)	
Ratio of female employees (previous	0.002	*	0.000		0.000		0.001	
year)	(0.001)		(0.001)		(0.001)		(0.001)	
Ratio of part-time employees	0.002	***	0.002	**	0.002	**	0.002	***
(previous year)	(0.001)		(0.001)		(0.001)		(0.001)	
Coefficient of determination	0.677		0.651		0.651		0.666	
F	17.45		14.97		15.04		16.69	
Sample size	1424		1424		1424		1424	

(Notes) Industry and year dummies were added to the explanatory variables. The least squares method was used, weighted for the number of workers by industry category. Heteroskedasticity-robust standard error was employed. Figures in parentheses represent standard error. ***,**, and * represent 1%, 5%, and 10% levels of significance respectively.

(4) Rate of Growth of Employment of Middle-aged and Older Workers

To continue, we will change our perspective and consider what effect the aging of industries and sectors has on the employment of middle-aged and older workers. The same type of analysis will be conducted, but this time using the rate of growth of employment of workers aged 45 and above as the explained variable. If the employment of younger workers is increasing in industries in which there are low numbers of younger workers, it would be unsurprising to find that employment of middle-aged and older workers is declining in industries in which there are large numbers of such workers. Using data from the Basic Survey on Wage Structure and the JIP database, a restricted regression analysis was conducted using industry and sector dummies, with the age structure as the explanatory variable.

The results are shown in Figure 5-5. Columns (1) to (3) shows results obtained using data from the Basic Survey on Wage Structure. The result for the ratio of workers aged 30 and above is negative and not significant, while the result for the ratio of workers aged 45 and above is negative and displays a 1% significance. The result for the ratio of workers aged 55 and above is negative with a significance of 5%, and the result for the average age is also negative with a significance of 5%. Columns (4) to (6) show results obtained using data from the JIP database. While the result for the ratio of workers aged 30 and above is positive with 10% significance, the results for the ratio of workers aged 45 and above and the ratio of workers aged 55 and above are both negative with a significance of 1%, and the result for the average age is negative but not statistically significant. These results indicate that employment of middle-aged and older workers is actually declining in industries in which there is a high ratio of these workers.

Figure 5-5 Results for the rate of growth of employment of middle-aged and older workers (45 and above)

Data from Basic Survey on Wage Structure	(1)		(2)		(3)		(4)	
Ratio of workers aged 30 and above (previous year)	-0.167							
	(0.149)							
Ratio of workers aged 45 and above (previous year)			-0.624	***				
			(0.203)					
Ratio of workers aged 55 and above (previous year)					-0.579	**		
					(0.276)			
Average age (previous year)							-0.013	**
							(0.007)	
Coefficient of determination	0.227		0.240		0.233		0.232	
F	3.02		3.07		3.19		2.94	
Sample size	741		741		741		741	
Data from JIP database	(5)		(6)		(7)		(8)	
Ratio of workers aged 30 and above (previous year)	0.085	*						
	(0.050)							
Ratio of workers aged 45 and above (previous year)			-0.186	***				
			(0.070)					
Ratio of workers aged 55 and above (previous year)					-0.223	***		
					(0.073)			
Average age (previous year)							-0.001	
							(0.002)	
Coefficient of determination	0.613		0.615		0.617		0.611	
F	14.06		14.3		14.91		13.86	
Sample size	1424		1424		1424		1424	

(Notes) Industry and year dummies were added to the explanatory variables. The least squares method was used, weighted for the number of workers by industry category. Heteroskedasticity-robust standard error was employed. Figures in parentheses represent standard error. ***,**, and * represent 1%, 5%, and 10% levels of significance respectively.

4. In Place of a Conclusion

This paper has analyzed the effect of the aging of Japanese society on employment among young people by estimating the rate of growth of employment among the young. The results showed that since 1990, the rate of growth of employment of younger workers has been high in industries in which there are low numbers of young people, while the rate of growth of employment of middle-aged and older workers has been low in industries in which there are large numbers of middle-aged and older workers. We may therefore conclude that Japanese companies have adopted a strategy of reducing (or controlling the increase of) the numbers of employee categories of which they have an excess, and of increasing (or controlling the reduction of) the numbers of employee categories of which they have a shortage, seeking to maximize the benefits available from an optimal employee age structure.

This result does not appear to accord with the "replacement effect theory," but this is not something that can be stated categorically. Two effects can be seen to be the component elements of the "replacement effect theory." The first of these is the effect of the margin for new employment of young people being reduced when the number of individuals who have concluded employment contracts as full-time employees increases. The second is that this effect of impeding new employment is greater in companies with older age structures. The existence of this second effect is precisely why it can be concluded that an increase in the ratio of middle-aged and older employees restricts new employment of young people. With regard to the first effect, we may assume that companies actually exist which have no margin for the employment of young people because they seek to maintain employment of their middle-aged and older employees. However, this paper has not obtained results that accord with the second hypothesis, that this effect increases in magnitude as the age structure of the company becomes older.

This analysis has employed different indices and data to those employed by Genda (2004), and this fact can also be considered to lie behind the differences in the conclusions of the analyses. To repeat, the main focus of Genda's analysis was the job accession rate among young people, while the main focus of this paper has been the employment growth rate among young people. In addition, while Genda employed workplace-level cross-sectional data, this paper has employed pooled data formed from industry-level cross-sectional and time series data. It cannot be considered surprising that these differences have had a significant effect on the outcomes of the analyses. From this perspective, while the results reported in this paper may not absolutely support the "replacement effect theory," caution must be exercised in their interpretation.

Assuming that the results of this analysis are accepted, what meaning will this have for the issue of employment among young people in Japan? If Japanese companies are attempting to maintain optimal age structures, this trend should have had a positive effect on employment among young people. Despite this fact, the employment environment for young people has worsened significantly since the 1990s. This indicates the emergence of other disadvantageous factors for young people (for example, a decline in the rate of company growth, or increased uncertainty in the business environment).

Again, if the results of this analysis were to be accepted, it may be concluded that there is a low risk that employment among young people will be adversely affected by the future aging of Japanese society. Certainly, it is possible that the risk is low that an increase in the average age of workers will have a significant impact on employment opportunities for young people. However, it is also highly possible that the active entry of elderly people and married women into the labor market and their accession to jobs will function to restrict employment of young people. This is a different effect to the effect of the age structure. In addition, if companies utilize elderly people further in future, it is possible that this trend will enhance their relationship of substitution with young people. It will therefore be necessary in future to carefully observe the status of substitution of other workers for young people.

[Notes]

*1 The median age in each age group was used as the average age in calculations. For example, in the case of the 20-24 age group, the median age of 22 was employed in calculations. However, for the 65 and above age group, 67 was used as the average age. The same system is employed throughout this paper.

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